SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1900.

GENERAL PHYSICS.

442. *Determination of the Earth's Density and Gravitation Constant.* **A. Gerschun.** (Comptes Rendus, 129. pp. 1013–1015, Dec. 11, 1899.)—If a liquid be in equilibrium under the earth's attraction, and a heavy spherical mass is made to approach it, the surface of the liquid assumes a new form of equilibrium, which is a surface of revolution about the line joining the centre of the heavy sphere with that of the earth. Denoting by R the earth's radius, M its mass, r the radius of the heavy sphere, μ its mass, and h the distance of its centre from the free surface of the liquid, the author finds for the radius of the osculating sphere $\rho = \frac{Mh^2}{\mu R^3 + Mh^3} hR$, approximately, and thence derives the formula—

$$\frac{R}{\rho} = 1 + \frac{d}{\delta}\alpha^3$$

in which d is the density of the heavy sphere, δ the density of the earth, and $\alpha = r/h$.

If therefore α be constant, ρ is independent of the radius of the heavy sphere and depends only on its density. It thus enables the experimenter to use for the heavy sphere a small sphere of platinum.

The liquid is a bath of mercury. If ρ can be determined, δ, the earth's mean density, is thus known. The method used for determining ρ is the one employed by Foucault for the verification of plane optic surfaces. The details are to be published in the Journal of the Russian Astronomical Society.

S. H. B.

443. *Action and Reaction.* **A. Broca.** (Comptes Rendus, 129. pp. 1016–1019, Dec. 11, 1899.)—The writer refers to a memoir by Vaschy in which is shown the existence of vector masses acting on a scalar pole in any field of force. Let X, Y, Z be the forces acting on the pole. Then these vector masses have, according to Vaschy, the forms—

(1) $$M_x = \frac{1}{4\pi}\left(\frac{dZ}{dy} - \frac{dY}{dz}\right), \text{ \&c., where no potential exists,}$$

and—

(2) $$N_x = \frac{1}{4\pi}(nY_1 - mZ_1), \text{ \&c.,}$$

at a surface of discontinuity. Here l, m, n, are direction cosines of the surface. Broca shows that the vector masses (2) have no existence, and that (1) form "conservative" tubes notwithstanding the discontinuity, and therefore that their action on a scalar mass is analogous to the action of a magnetic shell. There is thus equality between action and reaction in this case.

The author refers to Maxwell's Theorem (p. 95 of his work) which he puts in the form that on a surface of discontinuity in the field of a vector only the component normal to the surface can be discontinuous, unless the force be infinite. From this he proves that the tube of force is "conservative."

He draws three corollaries: (1) That potential cannot be discontinuous—though there is what he calls a "couche de passage" of rapid variation in passing from one side of a surface to the other; (2) The electric current cannot be discontinuous; (3) All electric currents are closed, as Maxwell teaches. S. H. B.

444. *Standard Kilogramme.* **M. Thiesen.** (Abstract in Zeitschr. Instrumentenk. 19. pp. 312–317, Oct., 1899, from Trav. et Mém. du Bureau Intern. des Poids et Mesures, 8. 1893, and 9. 1899.)—The work of comparing the forty national standard kilogrammes with the international standards has now been finished. Instead of comparing all the national standards in every possible combination, they were divided into six groups of seven and seven groups of six, and all possible combinations were carried out within each group, thus diminishing the number of comparisons from 780 to 231. The standards, or "prototypes," were all made of an alloy of 90 per cent. platinum and 10 per cent. iridium. Their shape is that of a cylinder of height equal to its diameter. The density of each standard was determined by weighing in water. The comparison of each standard with the international standard was carried out by means of Runge's vacuum balance, provided with automatic changing device and a device for automatically centring the cylinder on the cross serving as a scale. The probable error in the mass of each standard is 0·0020 mgr. when compared with the mean of all national standards, 0·0022 mgr. compared with the international standard, and 0·0028 mgr. compared with any other national standard. E. E. F.

445. *Registration of Vertical Movements.* **N. Ach.** (Zeitschr. Instrumentenk. 19. pp. 309–312, Oct., 1899.)—The vertical motions of the centre of gravity of a ship at sea are recorded photographically by means of an aneroid barometer carrying a mirror instead of a pointer. The limit of accuracy of the records is about 1 m., which corresponds to an ordinate of about 2 mm. on the curve. Greater accuracy can be obtained by means of a micrometric eyepiece, but not in the photographic records. The apparatus is suspended by a double Cardani suspension as used by Julius. E. E. F.

446. *Tachometer.* **R. A. Fessenden.** (Elect. World and Engineer, 34. p. 739, Nov. 11, 1899.)—A description of what is practically an electrical hand tachometer. It consists of a disc commutator of six equal sectors, rotated by the shaft; three small brushes rest against this commutator, being arranged with angles of 90°, 90° and 180° between adjacent brushes. One brush is connected to a small storage battery, one to a condenser, and the other to a specially damped Weston voltmeter, or a ballistic galvanometer. The other terminals of the battery, condenser, and voltmeter are coupled together. The instrument may be standardised absolutely or by direct comparison with an ordinary speed indicator or counter. Any change in the voltage of the

battery is compensated for by the adjustment of a non-inductive resistance in series with the voltmeter.

The advantages are : (1) Readings may be taken at any distance from the rotating part ; (2) A range of from 1 to 1500 is obtained, and its readings can be relied upon for accuracy to 1·5 of 1 per cent. ; and (3) Extreme sensibility, the passing of the belt joint over the pulley or the change of speed of a loaded engine during its stroke being easily perceived.

It is also useful when used in conjunction with a synchronous motor for ascertaining the frequency of currents in alternate current mains. E. D. P.

447. *Physical Properties of Nickel Steel.* **W. H. Warren** and **S. H. Barraclough.** (Royal Soc. N.S. Wales, Journ. & Proc. 32. pp. 150–168, 1898.)—After reviewing previous work the authors give the results of tests made by themselves on specimens of Krupp's Mild (with 3 per cent. Ni), Medium-hard (8 per cent. Ni), and Non-rusting (25 per cent. Ni) Steel. Using round test-pieces 6 in. in length, with a cross-sectional area of 0·29 sq. in., and recording the results in the order above named (Mild, Medium-hard, and Non-rusting), the limits of elasticity of the specimens were respectively 19·2, 23·7 and 13·1 tons per sq. in., the yield points were 23, 36, and 23·7 tons per sq. in., and the breaking loads 32·9, 51·4, and 47·9 tons per sq. in. ; the elongations after fracture were 22·3, 16·6 and 33·3 per cent., and the co-efficients of elasticity in tons per sq. in. were 12,375, 12,110, and 11,760. Discs immersed in dilute sulphuric acid (1 of strong acid : 100 of water) at 170°–180° F. for 24 hours lost in weight as follows : Non-rusting = 0, Mild = 1·51 per cent. on 743 grains, and Medium-hard = 6·56 per cent. on 754 grains. A disc of Low Moor boiler-plate lost 5·06 per cent. on 731 grains under the same conditions. With the exception of the broad statements quoted above as to percentage of nickel, no information is given as to the composition of the samples. W. G. M.

448. *Alloys of Nickel and Iron.* **R. A. Hadfield.** (Instit. Civ. Engin., Proc. 138. pp. 1–125. Discussion, pp. 126–167, Oct., 1899.)—In this monograph the physical and mechanical properties of pure nickel and of practically carbonless alloys of iron with from 0 to 50 per cent. of nickel are given at length, and in an appendix an outline is given of the metallurgy of nickel. All samples were magnetic, the specimen containing 24·5 per cent. Ni being least so (it was only slightly attracted in bulk, though readily picked up when in small fragments), but even this was very magnetic when forged, whether before or after annealing. The author is of opinion that the alloys which gave abnormal magnetic tests in the hands of other experimenters (being non-magnetic when heated to 520° C. and remaining so after quenching) must have contained notable proportions of carbon. The tensile strength per sq. in. of iron increased slowly from 30 tons with no Ni, to about 49 tons in unannealed specimens (or 47 tons annealed) with 7·6 per cent. Ni ; and then rapidly to about 94 tons (or 89 tons annealed) with 11·4 per cent. Ni ; with higher percentages of nickel the tensile strength fell off. The 11·4 per cent. alloy also showed the highest elastic limit and resistance to compression, but at the same time gave evidence of low ductility. The paper concludes with an account of the uses of nickel steel for hydraulic cylinders, forgings, material for armour and its attack, guns, boiler-plates, and fire-box stays. In the discussion on the paper, **Barrett** gave the specific resistance in microhms per cc. of iron alloys containing from 0·14 to 0·19 per cent. C, 0·6 to 1·0 per cent. Mn, and 0·21 to 0·3 per cent. Si, and varying percentages

nickel as follows : 1·9 per cent. Ni = 21·5 ; 3·8 per cent. Ni = 24·9 ; 11·4 per cent. Ni = 38·2 ; 19·6 per cent. Ni = 43 ; 24·5 per cent. = 55·5 microhms. A sixth alloy containing 31·4 per cent. Ni, but with 0·7 per cent. C. and 0·8 per cent. Mn, had a spec. res. of 86 microhms. All these tests were made with unannealed specimens, the resistance of the specimens after annealing was less by about 6 per cent. for the pieces containing comparatively little Ni, and 16 per cent. for the 31 per cent. alloy. With alloys containing much manganese the presence of a little Ni had no marked effect on the conductivity. Attention is specially directed to an alloy containing 25 per cent. Ni, 5 per cent. Mn, and 0·6 per cent. C, which had a spec. res. of 97·52 microhms per cc., and a temperature coefficient of 0·085 per 1° C. This is the highest spec. res. of any alloy known in commerce, being 60 times that of pure copper, and 4½ times that of German silver. The alloy is described as being easily worked and a beautiful material. With regard to magnetic properties, a comparison is made between iron-nickel alloys and a good commercial iron, which gave a maximum induction of 17,480 in a field of 45 c.g.s. units, with a retentivity of 7,000 and coercive force of 1·66 measured in terms of H. The addition of a little Ni had but slight effect ; the test with a sample containing 3·8 per cent. Ni gave (with same magnetic field) max. induct. = 17,480, retentivity but slightly increased, coercive force = 8·75. But the 11·4 per cent. alloy showed a drop to 8,560 (max. induct.), 4,800 (retentivity), and an increase in the coercive force to 17·15. The 19 per cent. alloy showed the highest coercive force of any alloy of steel yet examined. W. G. M.

449. *Propagation of Explosive Air Waves.* **P. Vieille.** (Comptes Rendus, 129. pp. 1228–1230, Dec. 26, 1899.)—Explosives are not necessary to produce waves of a velocity much higher than that of sound waves. When air is closed off by a collodion diaphragm at the end of a tube, and is compressed by a piston, the wave generated when the collodion bursts has a very high velocity. Some collodion diaphragms will burst at a pressure of 27 atmospheres, and the wave generated in them is propagated at a rate of more than 600 m. per second. The rate decreases by about 20 m. per second for every metre traversed, until it becomes the ordinary velocity of sound. E. E. F.

450. *Air-Resistance.* **G. H. Bryan.** (Nature, 61. pp. 107–109, Nov. 30, 1899.)—Deals with recent researches of Le Dantec and of Canovetti. As in 1893, Le Dantec makes the surface under test slide down a vertical wire. The start releases an electric recording device, and the current is broken when the body strikes the buffer at the end of its descent, which occupied 1, 2, or 3 seconds. The experiments were conducted in the nave of a chapel ; it is necessary to avoid all disturbance of the air, even by persons moving. A surface, 1 m. square, moving with a velocity of 1 m. per second, experiences a resistance of 81 grammes ; the form of the plate, circular, square, or triangular, is of importance—an observation made also by O. Mannesmann—and the resistance would appear to be proportional to the length of the contour. The law that, within certain limits, the resistance is proportional to the square of the velocity, is verified.

Canovetti suspends his bodies from a 3 mm. wire, 370 m. in length, stretched along the slope of a hill in the open air. As the wire hangs in a catenary, the body was arrested 90 m. before reaching the end of the wire. But the weight of the body affected the curve, and the time was measured simply by watching a chronometer. Yet the observations seem to be of practical value, as he finds a resistance of 90 gms. (instead of Le Dantec's

81 gms.). In most experiments he employed circular, not square, plates, and attached long or short cones to the rear of the plate (resistance reduced to 60 gms.), to both rear and front (resistance 15 gms.), or a hemispherical cap to the front (resistance 22·5 gms.), &c. He also tried bodies of the shape of a Chalais balloon, a long cone and a hemisphere joined by their bases, enveloped in a net; the resistance was 80 gms., and largely due to the net. H. B.

451. *Aeronautics and Soaring Machines.* **L. Hargrave.** (Royal Soc. N.S. Wales, Journ. and Proc. 32. pp. 55–65 and 209–222, 1898.)—These two papers deal with experiments on soaring carried out on models. The author differentiates between soaring and gliding. In the former a bird remains stationary, or it may be rises in a horizontal wind without flapping its wings, while in gliding the bird moves forward while slowly descending. Lilienthal's experiments were on gliding. The power which a bird has of soaring is attributed to the curved part of the wing nearest the body, there being a deep hollow on the under side of the wing, immediately behind the edge which first meets the wind. The air dividing on this edge, part goes over the wing and part under, and this latter part generates a vortex in the deep hollow on the under side of the wing, which vortex causes a greater pressure on the under side than there is on the upper side, and so gives the lifting power. The author considers the problem of the soaring bird as analogous to that of a ball retained in its position in front of a nozzle from which a high-pressure jet of water is issuing.

The models experimented with have curved surfaces representing the curved parts of the wings, and also other surfaces to represent the plane tips of the wings and the tail, which are requisite to give stability; these latter surfaces are like those on a cellular kite. One form of model has a long tube as base, the ends of the tube being loaded with lead. To each end of this tube, on the upper side, is attached a circular cylinder of tin plate, the axis being parallel to the tube. These two cylinders and the rod form a cellular kite. Between the two cylinders the curved surface is attached. It is made from sheet vulcanite, the sheet being three or four times as broad as it is long. A vertical section of the bent sheet is circular at the forward end, the tangent at the very end being vertical; then when the tangent comes nearly horizontal the form changes to the hyperbolic, and maintains that form to the other end. This curved surface can be angled bodily to the rod. Several other forms of model are described.

In the experiments, the models are tethered by a cord to a horizontal cord stretched between the tops of two high poles. The models then take up a position to windward of the tethering-point, sometimes on a level with it, and sometimes above it. J. B. H.

452. *Horizontal Pendulums.* **O. Hecker.** (Zeitschr. Instrumentenk. 19. pp. 261–269, Sept., 1899.)—A description of the construction of a horizontal pendulum apparatus, and an account of the comparison of the behaviour of two horizontal pendulums under the influence of various disturbances of the earth's crust. The pendulums were fixed beside each other on the same pillar, and their movements recorded on the same registration apparatus. The observations show that, with horizontal pendulums, comparable results can be obtained only when the pendulums are similar, have the same time of oscillation, and when, moreover, the same law of diminution of amplitude holds for both. J. J. S.

453. *Earthquake in Sicily and Southern Italy on Nov.* 16, 1894. **A. Riccò.** (Accad. Lincei Atti, 8. pp. 3–12 and 35–45, 1899.)—These papers contain a preliminary account of the investigations by the Commission charged by the Government to study the earthquake. The first deals with the intensities, isoseismic lines, and instrumental records. With the aid of information derived from 170 inhabited centres, of which 80 were actually inspected by the Commission, the area affected was divided by 10 isoseismic lines. These are shown on a map which, for purposes of comparison, gives also the isoseismic lines of the earthquake of 1783. Comparing it with a geological map, the author shows that the lines follow the outlines of the great crystalline masses. An attempt is made, but without success, at comparing the damage done to property. The failure arises from the fact that in the large centres of population houses are larger and better built than in small country places. The number of casualties was fortunately very limited, owing to warning shocks. The amplitudes of the vibrations, as registered by the seismometrograph (Brassart's smoked plate) of the Catania observatory were for the first 9 seconds less than 1 centimetre, 23 seconds later, when the maximum was attained, their north-south component measured 43 mm., their east-west component 40 mm., and their vertical component 9 mm. The duration of the earthquake was felt by persons for a few seconds only, but Vincenti's delicate instrument at Siena registered a duration of 11 minutes. The first paper concludes with a table giving the observatories' distances from the epicentre, particulars of the seismometers, registered duration of the shock, amplitude and direction of the vibrations.

The second paper deals with the velocity of the moving earth or ground, the velocity of propagation, depth of hypocentre, repetitions, and comparisons with the earthquake of 1783. The author calculates the horizontal component of the velocity of the ground from the distances to which objects were projected from the tops of buildings. The velocity varied from a few decimetres to 3·9 metres at Sinopoli. The author finds the mean velocity of propagation to be 2 kilometres per second, and, assuming that the disturbance was propagated in a spherical form, calculates the depth of the hypocentre to be 159 kilometres. But the hypothesis of constant velocity is found not to hold ; as the density and elasticity of the earth's crust increase with the depth, the wave-fronts are not spherical and equidistant ; making certain corrections the author determines the depth of the hypocentre to be 172 kilometres. He then considers Dutton's method of finding the depth of the hypocentre, but finds that none of the depths already found agree with it, and as it also does not agree with the scale of intensities for Rossi-Fovel, he discards it. With regard to warning shocks, Mercalli states that throughout Calabria from Nov. 10 a number of very slight shocks were recorded by instruments ; and the singular fact is noted that for two months previously great excitement prevailed in Calabria, as it was said that the Madonnas of Palmi, Radicena, and Seminara, moved their eyes, perspired, &c., and some plague was expected. Touching the subject of repetitions, the author calls attention to the fact that the earthquake took place when the moon was in Perigee ; altogether he counts twelve repetitions, each of which occurred when the attraction of the sun and moon was a maximum ; he concludes that these coincidences cannot reasonably be attributed to chance. The author compares the earthquake of 1783 with that of 1894, and concludes that the latter may be taken as a repetition of the former ; but its greatly diminished intensity gives rise to the hope that in future we may not again witness such a disastrous occurrence. A. G.

454. *Earthquake-Sounds.* **C. Davison.** (Phil. Mag. 49. pp. 31–70, Jan., 1900.)—The observers of earthquake-sounds are of great number, and differ considerably in their powers of hearing. The variety of earthquakes are also of great number. One can therefore only obtain a satisfactory idea of the nature and peculiarities of the sounds observed from a multitude of interesting descriptions, such as those given in the original paper.

The sounds are generally of low pitch; and one person may hear a sound whilst another cannot hear it in the least. Again, as the audibility of a note of low pitch depends on its intensity, a person may hear it for some time and then suddenly cease to be aware of its existence; or it may have been in existence for some time before he is conscious of the fact. Notwithstanding the difficulties due to physiological causes, from the frequent comparison of the sound to that of passing vehicles, one may say that the intensity of the sound is often of varying magnitude, and that it sometimes increases to a maximum and then dies away. In addition to the varying sound there are often erratic noises which do not always produce the same effect on all observers. Thus, "in the Hereford earthquake we find that at Hereford a crash or bomb-like explosion was noticed during the rumbling sound by four observers, while four others describe the sound in terms which imply uniformity of character."

An attempt is made to map out the area subject to the sounds with the aid of isacoustic lines. "An *isacoustic line* may be defined as a line which passes through all places in which the percentage of persons who hear the sound is the same." There are marked differences between the isoseismal and the isacoustic lines. The paper also deals with the relation between sound-audibility and geological structure, the relations between the intensities of the shock and sound, the relations between the sound area and the disturbed area, the time relations of the sound and shock, and the relative durations of the sound and shock.

Finally, a theory is given of the causes of the sounds when the earthquakes are of a non-volcanic character. The supposition is made that the majority are due to the growth of faults. The seismic centre is not a point, but "a surface inclined to the horizon, and is often of great length in a horizontal direction." It is assumed that the large and slow vibrations come from the central region, whilst the small and rapid vibrations come from the outskirts. A. G.

455. *Secchi's Fourth Type of Stellar Spectra.* **G. E. Hale** and **F. Ellerman.** (Astro-Phys. Journ. 10. pp. 87–112, Aug., 1899.)—The authors commence by stating the difficulties which have hitherto prevented any systematic examination of this group of celestial objects. None of the stars exceed the 5·5 magnitude, being thus beyond the reach of any but the largest instruments, and moreover, when examined photographically, the blue region of the spectrum is so feeble that but little is recorded with normal plates and exposures. With the instrument at the author's command, the 40-inch Yerkes refractor of the University of Chicago, the first difficulty is rendered much less noticeable, while the character of light emitted by these stars has been utilised by employing isochromatic plates and long exposures. The work was systematically commenced in 1897. After reviewing the early work by Vogel and Duner the authors give a detailed description of their apparatus, of which several illustrations are included. A special interpolating machine was designed and made for the determination of wave-lengths.

In this, the first paper on the subject, attention is confined to the star 152

Schjellerup, which is the brightest object of this class. A photograph of the spectrum of this star is given, extending from λ 4800 to λ 6300. From the evidence of their photographs, the authors consider the spectrum to contain two *bright* lines, and draw special attention to that at λ 5592. C. P. B.

456. *Wave-Length of Green Corona Line.* **W. W. Campbell.** (Astro-Phys. Journ. 10. pp. 186–192, Oct., 1899. Paper read at the Third Conference of Astronomers and Astrophysicists, Sept. 7, 1899.)—The author describes the apparatus he had charge of with the Crocker expedition sent out from the Lick Observatory to observe the total eclipse of the sun, January 22, 1898, in India. His original intention was to get photographs of the spectrum of the corona on a large scale in order to determine the law of rotation from the change of wave-length of the lines ; but on examination of his plates he found the wave-length of the chief corona line in the green to be λ 5303·26, instead of λ 5316, which has been the accepted value for many years past. This had also been mentioned by Lockyer a few months previously. It is therefore important to determine the wave-length as accurately as possible at the next eclipse, as there may then be a possibility of its origin being determined.
C. P. B.

457. *Corrections to Absolute Wave-length Determinations.* **E. B. Frost.** (Astro-Phys. Journ. 10. pp. 283–285, Nov., 1899.)—In the reduction of spectroscopic observations of celestial objects it is always necessary to apply certain corrections to the observed wave-lengths on account of the various movements of the earth and other bodies, which movements cause displacements of the spectrum lines from their normal positions. Until recently two of these corrections have been neglected owing to their minuteness, but the recent advances in the accuracy attainable in the determinations of velocity in the line of sight render it important that they should in future be taken into account.

The first of these is due to the effect of the eccentricity of the earth's orbit, and varies from 0·011 tenth metre for λ 6563 to 0·007 for λ 3934.

The second correction is the diurnal one, due to the earth's rotation. This for the latitude of Baltimore would vary from 0·008 tenth metre to 0·005 tenth metre. Thus an absolute determination of wave-length might from these two causes be in error to over one-hundredth of a tenth metre, the resulting velocity being wrong to more than one-half a kilometre per second.
C. P. B.

458. *Sun-Spot of September and October*, 1898. **A. Elvins.** (Canad. Instit., Proc. 2. 2. pp. 35–38, Sept., 1899.)—The author observed the groups of the sun-spots from September 4, probably their second day near the eastern limb, to September 17, and again on their reappearance on September 27 or 29, missing only a few days, down to October 10 ; on October 12 the spots had disappeared. Sketches taken are reproduced. The diameter of the great spot is estimated at 43,000 miles (sun diameter 800,000). The spots changed very much in appearance. As the groups in the train of the large spot seemed to be drifting towards the latter in September and to precede it in October, he considers that dark matter floating and drifting, possibly at different levels, in the sun's atmosphere cuts off the light of the photosphere below. He does not discuss the extreme agitation observed by D. E. Hadden during two hours about noon, September 7 : the H*α* line was reversed and distorted, black jets proceeding from each side in several places,

and, on opening the slit slightly, intense scarlet flames were seen over the large spot; many lines (D_1 and D_2) were widened. Auroras were reported from many places in Canada, especially on the days when the spots were near the limbs and, still more, when in the central solar meridian; the magnetic disturbances were most marked at the latter time. A terrific hurricane swept the Windward Islands on September 10 (time of central meridian position) and another occurred at Niagara (eastern limb position). The spots were near the solar equator, but they belong to a minimum sun-spot period; as a rule, a new cycle commences far from the equator. H. B.

459. *Photographic Determination of Stellar Parallax.* **F. Schlesinger.** (Astro-Phys. Journ. 10. pp. 242–245, Nov., 1899.)—This paper, which was read at the Third Conference of Astronomers and Astrophysicists at Chicago, September 8, 1899, consists of a series of suggestions for improvements in the methods of determination of stellar parallax.

The two most important means for this research are photography and the heliometer. The author considers that while measures found by photography are not inferior in accuracy to those made with the heliometer, it has much to recommend it on the score of economy of time. The disadvantages to which photography is liable require special attention for their elimination.

The difficulty, owing to the star under examination for parallax being usually several magnitudes brighter than those with which its position is to be compared, he proposes to remedy by rendering the photographic film locally less sensitive in the region where it is known the central bright star will impress its image.

Another possible serious source of error is the chance of distortion of the film after exposure. This may be detected by a modification of Wilsing's process, viz., by taking two pictures on the same date close together on the plate; then putting the plate away without development and six months later exposing two more pictures of the same object symmetrically with the first pair on the same plate. By this means any linear distortion, however violent, will not affect the measures for parallax.

A third source of error—optical distortion—may be introduced by the frequent reversals of the telescope on its axes. This may be partially obviated by providing means for revolving the object-glass also. In measuring up the plates differential measures only should be used. C. P. B.

460. *Photometry of Orion Nebula.* **J. Scheiner** and **J. E. Keeler.** (Astro-Phys. Journ. 10. pp. 164–168, Oct., 1899.)—Keeler has obtained photographs of the Orion nebula on ordinary plates, and on isochromatic plates with a yellow screen, and finds that the two pictures, one given by the blue and violet rays chiefly, the other by the greenish-yellow part of the light, show considerable differences in the structure of certain parts of the nebulous mass. Scheiner criticises these results, drawing attention to the difficulty of comparing equal photographic effects on different plates. C. P. B.

REFERENCE.

461. *Variations of Nickel-Steels.* **C. E. Guillaume.** (Journ. de Physique, 8. pp. 553–556, Oct., 1899.)—A discussion of the changes in the expansion of bars of nickel-steel when subjected to various temperatures. (See 1898, Abstract No. 1115.) J. J. S.

LIGHT.

462. *Diffused Reflection of Light.* **H. Wright.** (Ann. d. Physik, 1. 1. pp. 17–41, Jan., 1900.)—Lambert's cosine law of diffused reflection, originally suggested by the flat aspect of the moon, has been shown to be nothing but a rough approximation, destitute both of theoretical justification and of experimental proof. The Lommel-Seeliger formula is also unsupported by the facts.

The author describes some measurements made with plates of various substances and colours in a state of powder, and of such thickness as to be just opaque. He confirms Lommel's supposition that with a given size of grain the coefficient of diffusion is independent of the wave-length. An important result obtained is that the cosine law does not apply to a constant angle of emanation and a variable angle of incidence, but that, on the other hand, the amount of light reflected varies as the cosine of the angle of emanation when the angle of incidence remains constant, at least in perfectly dull powders. There is no law which is symmetrical both as regards i and e. Natural light is not polarised by diffused reflection, but polarised incident light is completely depolarised. The observed variations from Lambert's law range from 4·6 to 10 per cent. E. E. F.

463. *Metallic Reflection.* **E. Hagen** and **H. Rubens.** (Zeitschr. Instrumentenk. '19. pp. 293–306, Oct., 1899; Mittheilung aus der Physikalisch-Technischen Reichsanstalt.)—The results of this investigation of the reflecting power of metals for the different wave-lengths, from 450 to 700 $\mu\mu$, have been already communicated to the Physical Society of Berlin. (See 1899, Abstract No. 992.) The present paper contains a detailed description of the apparatus used, which is of that magnificent type generally used in the Reichsanstalt.

The metallic mirrors used are, with a few exceptions, concave, and all of the same focal length. The source of light is a strip of platinum foil, kept incandescent by an electric current. This is placed in the focus of the mirror, then slightly displaced vertically so that the real image of the incandescent strip is seen a little lower than the strip itself. These two sources of light are then compared by a spectro-photometer. In the cases where the mirrors are plane a convex lens is placed in front of the mirror, the strip being at the focus of the lens. The amount of light absorbed by the lens is determined by comparing the results so obtained for a plane silver mirror with those obtained for a concave silver mirror of the same manufacture.

The prisms and lenses in the apparatus are of quartz, and the achromatic lenses are combinations of lenses of fluorspar and quartz. The spectrophotometer consists of a spectrometer with automatic adjustment of minimum deviation and with double slit, each slit having micrometer adjustment. A biprism is placed in front of the telescope objective, its edge being horizontal. Images of the source of light and its reflected image are thrown on the two slits by a lens in such a manner that the light which enters the two slits comes from the same part of the platinum strip, but from opposite sides of it, since one beam has been reflected. If the biprism is removed, two corresponding spectra are seen in the focal plane of the telescope. On replacing the biprism four spectra occur, two of which are exactly superposed (by adjustment). The eyepiece is then removed and a small slit placed in the

focal plane to cut off all the light, except the one wave-length in the double spectrum. The eye when looking through this slit sees the field of a uniform colour, but the upper and lower halves are not of equal intensity. Adjusting the micrometer screw of one of the slits makes the intensities equal, and the relative widths of the two slits gives the photometric comparison of the source and its image for that particular wave-length. The slits are experimentally standardised by placing a uniformly illuminated surface opposite them and photometrically comparing the spectra.

Besides the results previously given the following reflecting powers are also given here, the figures being percentages :—

For λ	450	500	550	600	650	700 μμ
Alloy of Brandes and Schünemann (41 % Cu + 26 Ni + 24 Sn + 8 Fe + 1 Sb).	49·1	49·3	48·3	47·5	49·7	54·9
Alloys of Ludwig Mach—						
No. I. (2 parts Al + 1 part Mg).	83·4	83·3	82·7	83	82·1	83·3
No. VII. (1 part Al + 1·5 part Mg)	83·4	82·5	82·1	83·8	84·9	84·4
No. XII. (1 part Al + 2·75 part Mg)	83·4	84·5	83·8	84·5	83	83·8

The first of the above alloys withstands severe exposure to the weather, and ordinary chemical reagents have no effect on it. J. B. H.

464. *Total Reflection.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 1. pp. 1–33, 1899.)—In a former communication (Gott. Nach., 1898) the author has shown that the phenomenon of so-called total reflexion can at least approximately be regarded as the reflexion of a plane wave, whose amplitude varies in the plane of the wave, on an opaque screen, which is bounded by lines parallel to the lines of constant amplitude in the plane of the wave. He has also, following Sommerfeld, dealt with the case of a perfectly reflecting screen. The fundamental conception of the present paper is that an absolutely black screen may be regarded as the surface of separation in a multifold Riemann space, of which one part represents the physical space. A vibration excited in the physical space passes out of the physical into another part of the Riemann space. This effect of the surface of separation is at least analogous to the action of the absolutely black screen, which neither transmits nor reflects light.

The author discusses the definition of an absolutely black body. The definition that it neither transmits nor reflects light, though for some purposes sufficient, is insufficient for the purposes of physical optics, because it may act in other ways on light in its neighbourhood. There may then be different kinds of absolute blackness, and the kind dealt with in the present paper is that for which the appropriate Riemann space is twofold.

A plane wave of light reaches the screen, bounded by an infinite line parallel to the plane of the wave. The normal component passes through the screen into the other part of the Riemann space ; the other component spreads over the screen, and there undergoes the variations which are known as Beugung. S. H. B.

465. *Astro-photographic Objective.* **H. Harting.** (Zeitschr. Instrumentenk. 19. pp. 269–272. Sept., 1899.)—An account of an objective for

astro-photographic work, made from a new silicate glass produced at the works of Schott and Co. in Jena. The glass exhibits such unusual behaviour as to partial dispersion that the secondary spectrum, so far as concerns the eye, is done away with, and for the purposes of astro-photography is considerably diminished. J. J. S.

466. *Portable Photometer for Incandescent Lamps.* **A. J. Rowland.** (Frank. Instit., Journ. 148. pp. 376–383, Nov., 1899.)—This describes a photometer, which the author has found especially good for candle-power of glow lamps. It is a Bunsen photometer with a movable carriage, holding the usual grease spot and mirrors. At one end of the instrument is a lamp-holder for the incandescent lamp whose candle-power is to be determined; at the other end, about 5 feet off, is an oil lamp. This holds enough oil to burn for four hours in use, and for an hour at a time with practically no change in its candle-power after once warming up and being set.

The method of working is to put a standard incandescent lamp in the holder, bring it to the required voltage by means of a rheostat, to give its standard candle-power of 16. The carriage with the grease spot is then set to this, and the 8-candle-power oil lamp is adjusted until the grease spot disappears. The standard lamp is then replaced by the one to be measured, and the carriage moved to give the reading in the ordinary manner.

This method of procedure does away with all difficulty due to reflection, difference in quality of the sides of the greased paper, difference of eye sensitiveness, &c., and does away with them all to such an extent that a real dark room is not required to get satisfactory results. All distortions come into every measurement in exactly the same way, and are negligible. The accuracy of a single reading will be within 1½ per cent. E. C. R.

467. *Standards of Light.* **S. E. Doane.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 451–453. Discussion, pp. 453–461, Aug., Sept., 1899.)—The author suggests that the incandescent lamp should be used as a primary standard. In the discussion **Steinmetz** pointed out that an acetylene standard could be used owing to the fact that the gas can easily be produced in chemical purity from copper acetylide Cu_2C_2, and that its light is of a perfectly white colour, equally suitable for incandescent and arc light photometry. The amyl acetate standard, the best available at present, has a great number of disadvantages, especially as regards colour. **C. P. Matthews** preferred the amyl acetate standard because of its steadiness and reproducibility. **W. M. Stine** pointed out that the failure of the incandescent light as a standard is due to its lack of reproducibility and constancy. The essential difficulty arises from the tendency of carbon to assume an allotropic form at a very high temperature; it is also impossible to produce homogeneous carbon filaments or to flash filaments until the surface assumes known radiating qualities. There are other difficulties such as the variation in the emissivity (both in the same filament and between different filaments), the blackening of the chamber walls, their indefinite absorption, and the vaporisation of the filament. **S. E. Doane,** in replying, said that he made a series of investigations and found that carbon surfaces of the two kinds gave only two emissivities; that is, all "treated" carbons gave exactly the same illumination per unit surface per watt radiated. There was absolutely no difference over wide ranges of specific resistance and specific gravity of these carbon deposits. Deposits can be made from any hydrocarbon, alcohol, or carbonaceous fluid, and the light radiated per unit surface per watt will be the same. E. C. R.

468. *Effect of Impurities on Gaseous Spectra.* **P. Lewis.** (Astro-Phys. Journ. 10. pp. 137–163, Oct., 1899.)—For many years the fact has been known that a small quantity of an impurity introduced into a gas considerably alters the appearance of the gaseous spectrum. The author has made a systematic examination of the effect of small additions of mercury vapour, oxygen, and water vapour on the spectra of hydrogen and oxygen. Special precautions were necessary to ensure the initial purity of the gases, and illustrations are given of the apparatus used. In the case of hydrogen, the introduction of mercury vapour caused a distinct reduction in the intensity of the hydrogen lines, the extent of the change varying with the quantity of mercury vapour present. With the hydrogen at 3 mm. pressure, the addition of 4 per cent. of its mass of mercury vapour reduced the visible radiant energy of the hydrogen by more than one-half. The effect of small quantities of oxygen added to hydrogen was also to reduce the intensity of the hydrogen spectrum, but to a greater extent than was the case with mercury-vapour. Water vapour also behaved very similarly to oxygen. In the case of the spectrum of oxygen, the addition of mercury vapour caused no change, but the least addition of hydrogen caused the mercury lines to be instantly visible. Throughout the experiments different results were obtained by the use of vacuum tubes having internal or external electrodes. C. P. B.

469. *Spectroscopy of Contrast Phenomena.* **G. J. Burch.** (Electrician, 43. pp. 811–812, Sept. 29, 1899. Abstract of a paper read before the British Association at Dover.)—In the words of the original, "The author has shown that by exposing the eye to bright sunlight in the focus of a burning glass, behind a screen composed of ordinary ruby glass, in conjunction with a gelatine film stained with magenta, a condition of temporary red-blindness may be induced, during which red flowers, such as scarlet geraniums, appear black, and red roses blue, although the observer is still perfectly able to distinguish colours composed of green, blue, and violet. Similarly, blindness to green, to blue, or to violet may be produced by fatiguing the retina with monochromatic light of sufficient intensity and of suitable colour. Experiments of the same character by Aitken, Hunt, Hess, and others, have since been brought to the author's notice. His own, which were made quite independently many years ago, differ from theirs in degree rather than in kind, the light used by these observers having apparently been not sufficiently intense to produce the full effect. . . . On Young's hypothesis all complementary colours and all contrast effects may be represented as coming under the same category as absorption spectra, in that they are due to the subtraction of something from the normal sensations which should result from the physical conditions of the experiment. According to Hering's theory, complementary colours cannot be regarded as due to the mere absence, or diminution, or suppression of certain elements of a complex sensation. So far as regards the effect of continuous light, the phenomena of artificial colour-blindness seem conclusive against the view of Hering." [See further Abstract No. 753 (1898).] E. E. F.

470. *Radiography with Three-phase Currents.* **Delézinier.** (Comptes Rendus, 129. pp. 1227–1228, Dec. 26, 1899.)—The employment of three-phase currents for radiography, by means of tubes with three poles, was theoretically indicated two or three years ago. Radiguet showed last year that when an induction coil is connected with two of the three terminals of a three-phase circuit, a Tesla flame appears between the terminals of the secondary. A tube does not light up unless the exhaustion is diminished, and then it lights

up throughout for an instant only and breaks. The author solves the problem by interposing an electromagnet with laminated core, consisting of two straight branches mounted at an angle of 120° and provided with two coils wound in opposite senses, in the primary circuit. The Wehnelt interrupter then works well for hours, and the light of the tube is so uniform and perfect that its intermittence can only be detected by stroboscopic methods. Of variable-rate interrupters, that consisting of a vertical coil with its lower end in mercury works best, especially if it be so regulated that the phase utilised is between $\frac{1}{2}\pi$ and $\frac{3}{2}\pi$. When the terminals of the indicator are reversed, the illuminated zone is not displaced. It is just as active photographically, and only a little less effective on the screen. E. E. F.

471. *Fluorescence in Solids.* **I. Schincaglia.** (N. Cimento, 10. pp. 212–223, Sept., 1899.)—In isotropic substances the light of fluorescence is never polarised : in crystals it generally, but not always, presents traces of polarisation. Topaz is the only crystal in which this light is completely polarised. Fluorescence of crystals depends in the greater number of instances upon chemical impurities in them, probably distributed in accordance with the structure of the crystal. In a crystal the particles causing fluorescence tend to vibrate either parallel or at right angles to the optic axis of the crystal. The colour of a crystal has no influence upon the production of fluorescence, but may affect the colour of the fluorescent light, if such be produced. In some cases the interposition of violet glass affects the colour of the fluorescent light produced. A magnetic field seems to produce no effect upon the colour of the fluorescent light, and not to cause anything analogous to the Zeeman effect. A. D.

472. *Phosphorescence of Used Röntgen Tubes.* **S. Leduc.** (Écl. Électr. 21. pp. 143–144, Oct. 28, 1899. Assoc. Franç. at Boulogne.)—A Röntgen tube after working remains luminous in the dark, with a uniformly distributed white light. This luminosity can be started afresh by heating the tube, and is a maximum at a particular temperature. It is not due to rarefied gas in the tube, for the result is the same if the tube have become filled with air. The glass of the Röntgen tube before being used does not present this phosphorescence ; it is an acquired property, apparently due to the action of high-tension electricity. The property is lost on repeated heating. A. D.

473. *New Radio-active Element.* **A. Debierne.** (Comptes Rendus, 129. pp. 593–595, Oct. 16, 1899.)—Another new element, bearing a close chemical analogy to titanium, found in the residues of pitch-blende. The radioactivity is a hundred thousand times that of uranium ; and the radiations render gases capable of discharging electrified bodies, excite fluorescence in platinocyanide of barium, and affect photographic films. The new substance is not, like radium, self-luminescent. A. D.

474. *Phosphorescent Sulphides.* **F. E. Kester.** (Phys. Rev. 9. pp. 164–175, Sept., 1899.)—A vertical cylinder of the test substance was rotated about its axis and was illuminated on one side through an aperture placed quite close to the cylinder. Then the emitted light was examined by a spectrometer, the slit of which was diametrically opposite the illuminating aperture. With a constant intensity of the source of illumination and a constant speed of rotation, however slow, the intensity of the emitted light, as observed in the spectrometer, remains the same. The energy of the exciting radiations

was measured by the deflections produced in a form of Crookes' radiometer. It has been found that under proper conditions the deflections are proportional to the energy of the radiations.

Observations were made upon calcium sulphide. The luminosity of the sulphide was found to be proportional to the intensity of illumination, under the conditions of the apparatus. For all wave-lengths of exciting light, widths of aperture, and speeds of rotation which were tried, it was found that the curves of intensities were straight lines. The results indicate that the rate of increase or of decrease at any intensity of phosphorescence depends upon the previous treatment which the luminous material has undergone.

J. J. S.

REFERENCES.

475. *Radiographic Vacuum Tubes.* **A. Buguet** and **V. Chabaud.** (Comptes Rendus, 129. pp. 591–593, Oct. 16, 1899.)—Description of focus tubes with the antikathode cooled, at its back surface, by a circulating stream of water. A. D.

476. *Refractive Indices of Crystals.* **C. Viola.** (Zeitschr. Instrumentenk. 19. pp. 276–282, Sept., 1899.)—A new method for determining the refractive indices of biaxial crystals is described. The method depends on the principle of minimum deviation, and a prism is employed. It is shown that this principle may be made use of for general purposes. (See also 1899, Abstract No. 1652.) J. J. S.

477. *Radiation Phenomena in a Magnetic Field.* **T. Preston.** (Nature, 61. pp. 11–13, Nov. 2, 1899.)—A short summary of some of the results obtained by the author in his investigations on this subject, especially with reference to their date of publication. It appears that the quartet form was first observed by the author in 1897 and its existence was independently proved by M. Cornu in the following year and announced in the *Comptes Rendus.* (See Science Abstracts, 1898, Nos. 910 and 1032, and Science Abstracts, 1899, No. 1000.) J. J. S.

478. *Magneto-Optic Rotation.* **A. Gray.** (Nature, 60. pp. 379–381, Aug. 17, and 404–407, Aug. 24, 1899.)—Discourse delivered at the Royal Institution. An account of the phenomena and theories of magneto-optic rotation with mechanical illustrations. J. J. S.

479. *Colour Photography.* **W. de W. Abney.** (Roy. Instit., Proc. 15, pp. 802–809, Aug., 1899.)—A description of Ives' and Joly's processes, and the principles involved. G. H. B.

480. *Photometry of Electric Incandescent Lamps.* **E. Liebenthal.** (Zeitschr. Instrumentenk. 19. pp. 193–205, and 225–240, 1899.)—A full experimental account, with mathematical discussions, of methods for measuring the mean spherical intensity and the particular variations from this, in differing types of lamps. A. D.

481. *Lummer-Brodhun Photometer.* **C. G. Knott.** (Phil. Mag. 49. pp. 118–120, Jan., 1900. Paper read before the Royal Society of Edinburgh, Dec. 17, 1899.) —Priority is claimed for W. Swan for the invention of this photometer, described by him in 1859.

482. *Telescope and Microscope Objectives.* **A. Leman.** (Zeitschr. Instrumentenk. 19. pp. 272–273, Sept., 1899.)—A discussion of formulæ for use in calculations applied to objectives of telescopes and slightly magnifying microscopes. J. J. S.

HEAT.

483. *Thermal Conductivity of Vulcanite.* **B. O. Peirce.** (Phil. Mag. 49. pp. 15–31, Jan., 1900.)—To measure the conduction of materials like vulcanite or glass, prisms were built up consisting of plates of the material, separated by layers of tin-foil; the faces of the prism were kept in contact with a steam supply and a reservoir of ice. Thermocouples inserted between the plates gave the temperature gradient and the amount of ice melted—the drip from the ice becomes steady when the experiment is continued for some hours—gave the flow of heat. The influence of the edges of the prism was shown to be negligible. The most suitable thermocouple consisted of thin strips of German silver and copper soldered end to end. The conductivity of vulcanite varies, according to the manufacture, from 0·000200 to 0·000317.
R. A. L.

REFERENCES.

484. *Pressure and Evaporation.* **E. H. Hall.** (Journ. Phys. Chem. 3. pp. 452–456 Oct., 1899.)—In a reversible isothermal process the volumes of the products on either side of the equation are not necessarily equal, and a correction should be introduced into the "equation of the reaction-isotherms" (Nernst, Theoretische Chemie, Ed. I., p. 510). The author applies the corrected equation to the evaporation of water and ice. T. M. L.

485. *Ratio of Specific Heats of Air.* **J. Rose-Innes.** (Phil. Mag. 48. pp. 286–287, Sept., 1899.)—A criticism of E. F. J. Love's paper on the Joule Thomson Thermal Effect. (See 1899, Abstract No. 1355.)

486. *Gaseous Mixtures.* **D. Berthelot.** (Journ. de Physique, 8. pp. 521–530, Oct., 1899.)—This memoir embraces little more than those referred to in Science Abstracts for 1898, No. 1231, and for 1899, No. 1153, as well as one (not abstracted) in Comptes Rendus, 128. pp. 1159–1160, 1899, which merely gives data to illustrate a former memoir. R. E. B.

487. *Thermodynamics.* **G. Jäger.** (Ann. d. Physik, 69. 3. p. 720, Nov., 1899.)—A short reply to W. Voigt *re* thermodynamics. E. E. F.

488. *Dilatation of Porcelain.* **T. G. Bedford.** (Phil. Mag. 49. pp. 90–97, Jan., 1900.)—This is a detailed account of the experiments referred to in Science Abstracts for 1899, No. 1880. R. E. B.

ELECTRICITY.

489. *Travelling Globular Spark.* **S. Leduc.** (Écl. Électr. 21. pp. 142–143, Oct. 28, 1899. Paper read before the Assoc. Franç. at Boulogne.)—Two fine polished metallic points arranged from 5 to 10 cm. apart, at right angles to a photographic plate or glossy gelatino-bromide paper, and connected with an electrostatic machine, will, especially if the paper rest upon a piece of glass and this upon a plate of metal, produce an effluvium round the positive and a luminous globule at the negative point. When the luminous globule has attained a certain size it detaches itself from the negative point (which becomes dark), and travels over the plate or paper, by a more or less irregular path, sometimes dividing as it travels, towards the positive point. When it reaches this, all luminosity is extinguished and the charges disappear as if the terminals of the machine had been connected by a conductor. If the positive point be lifted and laid down at a fresh place the phenomena recur in the same order. The globule takes from one to four minutes to travel the 5–10 cm. (See also 1899, Abstract No. 451.) A. D.

490. *Analysis of Spark Discharges.* **J. H. West.** (Elektrotechn. Ztschr. 20. pp. 747–750, Oct. 26, 1899.)—A photographic analysis of spark discharges was made by means of a "mutograph" in which the film was made to travel continuously with a speed of 1 to 7 m. per second. The sparks were produced with the aid of a Wehnelt interrupter. They travelled along approximately the same paths during successive discharges, but did not succeed each other regularly. On the negatives reproduced the sparks differ greatly in brightness. Their diameter is not uniform, and they are frequently brighter in the middle than at the ends. Some of the sparks are double or multiple, but these are not due to two or more simultaneous discharges, but to several sparks following in rapid succession, as shown by their tracks not being strictly parallel but approaching each other the closer the more their direction coincides with the direction of motion of the film. Continuous current sparks do not show these doublings or branchings. By direct vision the author proves that a duration of luminosity of about one-millionth of a second suffices to produce a distinct visual sensation. E. E. F.

491. *Radiations from an Electrified Point.* **S. Leduc.** (Écl. Électr. 21. pp. 144–145, Oct. 28, 1899. Assoc. Franç. at Boulogne.)—Insulate one pole of an electrostatic machine, and connect a fine point with the other, preferably the negative. This fine point presents a barely visible violet glow, but is the seat of powerful non-luminous radiation, possessing all the properties of ordinary ultra-violet rays, and capable of being used for photographic purposes. The photographic image of the source of radiation is a point. The rays are completely arrested by yellow, green, and red glass; and there is no resemblance to Röntgen rays. Leduc proposes the use of these rays in medical practice, *e.g.*, for lupus, as a convenient means of applying the known chemical effect of ultra-violet rays. A. D.

492. *Induction Coil Spark on Heating the Terminals.* **F. J. Jervis-Smith.** (Phil. Mag. 48. pp. 477–478, Nov., 1899.)—An Apps 10-inch induction coil, with a Wehnelt electrolytic break in the primary circuit; the pointed conductors

from the secondary coil so far separated that a spark would not pass and only a faint brush was visible; on heating the kathode terminal (not the anode) with a spirit lamp flame, sparks at once bridged the gap. Possibly the kathode point showered off heated metallic particles which enabled the sparks to pass along a heated path. A. D.

493. *Luminescence of Immersed Electrodes.* **T. Tommasina.** (Comptes Rendus, 129. pp. 957-959, Dec. 4, 1899.)—The author observed the luminescence of electrodes under the influence of the discharge of an induction coil. He filled some ordinary Crookes tubes with distilled water. The electrodes were aluminium discs attached to platinum wires. The discs became luminous, and so did the supporting wires when of aluminium instead of platinum. In many places minute gas bubbles traversed by sparks were observed, but the luminosity was not confined to those places. The discs could be photographed by their own light. The glow is essentially anodic, as evidenced by the fact that the current at break makes the anode luminous, and the current at make the kathode. The luminosity, though apparently continuous at both electrodes, is really alternating. Only aluminium, and to a less extent magnesium, show this luminosity, and they only show it when immersed in water, alcohol, or acidulated water, and not in dielectrics like petroleum or vaseline. E. E. F.

494. *Dispersion of Kathode Rays by Magnetic Force.* **R. J. Strutt.** (Phil. Mag. 48. pp. 478–480, Nov., 1899.)—Birkeland finds that when a narrow beam of kathode rays, produced by an induction coil, is deflected by a magnetic field, some of the rays are more deflected than others and the rays as a whole are so deflected as to produce by their impact a series of light bands of phosphorescence and intervening dark spaces. This Birkeland calls the magnetic spectrum. The author finds that there is no such spectrum when the kathode rays are produced by the continuous discharge of a battery of storage cells. The heterogeneity of the deflected rays is therefore not an essential property, but depends on some peculiarity of the induction-coil discharge, the kathode rays produced by a battery being homogeneous. The bright bands probably do not really coexist but depend on discharges occurring at different stages of each alternation. A. D.

495. *Energy of Kathode Rays.* **W. Cady.** (Deutsch. Phys. Gesell., Verh. 1. pp. 181–192, 1899.)—In the discharge of kathode rays on the theory of emission of charged particles, we have the energy Q (of N particles each of mass m and with velocity v) $= \frac{1}{2}Nmv^2$ ergs per second: and the current strength $i = N\epsilon$ where ϵ is the charge borne by each particle. For each particle the energy $V\epsilon = \frac{1}{2}mv^2$; so that the whole energy, in ergs per second, is $Q = NV\epsilon = iV$, and $iV/Q = 1$. But if part of the kathode rays are reflected, say the fraction r, and if the energy of the particles is reduced upon reflexion in the ratio $r' : 1$ while the reflected particles retain their charges, we have $iV/Q = (1 - r)/(1 - rr')$; or in the limit, if Merritt's result be accepted, that the magnetic deflectability, and therefore the velocity of the kathode rays, remains unaltered after reflection, $iV/Q = 1 - r$. Experiment shows that when we work within limits at which there is no superposition of conduction upon kathode convection, the value of iV/Q varies between 0·79 and 1·00. A. D.

496. *A Cyclical Electric Process.* **O. Dörge.** (Ann. d. Physik, 1. 1. pp. 1–16, Jan., 1900.)—A soap-bubble is taken through an electrical process

analogous to Carnot's thermodynamic cycle. In the first operation the soap-bubble is extended infinitely slowly while in contact with a conductor of very great capacity at a potential V_1. It is then disconnected, and further extended until the potential falls to another potential V_2. It is then connected with another conductor of great capacity at potential V_2 and contracted, and finally disconnected and further contracted until it reaches its initial stage. The author shows that the work done during the cycle is—

$$\frac{V_1}{8\pi}(V_1 - V_2)(r_b - r_a)$$

when r_a, r_b are the radii of the soap-bubble at the beginning and the end of the first operation respectively.

A counterpart of the second law of thermodynamics is obtained in the proposition that "no process is possible consisting only of a transfer of electric energy from a higher to a lower potential without the absorption or giving out of work." The author attempts to prove his conclusions experimentally, but with only partial success. Quantitatively the conclusions are, however, corroborated. E. E. F.

497. *Irreversible Processes.* **M. Planck.** (Ann. d. Physik, 1. 1. pp. 69–122, Jan., 1900.)—This is an exposition of the chief results of the author's investigations on the significance of the second law of thermodynamics for the phenomena of thermal radiation, considered from the point of view of electromagnetic theory of light. The phenomena of radiation and absorption are regarded as altogether electromagnetic, in the sense of being confined to the oscillation and resonance of certain entities analogous to Hertzian oscillators, connected in some way with the atoms of matter. This implies that the damping of an oscillator is entirely due to its radiation, and not, for instance, to Joulean waste. Optically, a wave-train of light is perfectly defined when its geometrical relations, its plane of polarisation, its intensity, and its wave-length are given. Electromagnetically, such a wave-train is by no means completely defined, since, owing to peculiarities in the distribution of the phases and amplitudes of the partial vibrations, its effect upon a resonator can have an infinite number of different values. The author eliminates this difficulty by introducing the conception of "natural radiation," in which the energy is distributed with absolute irregularity over the different partial oscillations composing the ray. This conception leads to the formulation and proof of a theorem analogous to the second law of thermodynamics. Incidentially, the author defines what he calls the "natural units" of length, mass, time, and temperature, which are independent of any particular body, such as the earth, and solely founded upon the velocity of light, the gravitational constant, and certain constants of radiation. The natural unit of length thus calculated is $4{\cdot}13 \times 10^{-33}$ cm., that of mass is $5{\cdot}56 \times 10^{-5}$ g., that of time $1{\cdot}38 \times 10^{-43}$ sec., and that of temperature $3{\cdot}50 \times 10^{32}$ deg. C. (See also 1899, Abstract No. 268.) E. E. F.

498. *Potential Gradient in Siberia.* **H. Benndorf.** (Akad. Wiss. Wien., S. ber. 108. pp. 341–370, 1899.)—An interesting account of observations of atmospheric potential gradient at Tomsk in midwinter. The practical difficulties are narrated. The results do not fully confirm any existing theory, but may be to some extent harmonised with them if dry ice or snow have, as Brillouin says it has, a negative-electricity-discharging sensitiveness to light about one-twentieth that of zinc. A. D.

499. *Atmospheric Potential Gradient in Egypt.* **F. Exner.** (Akad. Wiss. Wien., S. ber. 108. pp. 371–421, 1899.)—The author's formula $dV/du = A/(1 + Kp_o)$ where dV/du is the normal atmospheric potential gradient and p_o is the proportion of water vapour in the air, is now amply confirmed. It would seem as if a part of the negative charge of the earth was associated with water vapour, and varied in its vertical distribution. But there are variations of which this gives no explanation : and the effect of variations in the intensity of sunlight and in the temperature is, according to Quetelet and Braun respectively, to bring about such variations which, however, must run closely parallel to those associated with variations in the water vapour. According to Hallwachs, the intensity of blue and ultra-violet radiations, J, affects the potential gradient by promoting the direct discharge of negative charge, such as that borne by the earth, into the air ; and the law of the result is $dV/du = A/(1 + kJ)$. This effect is not confined to metals, as was at first thought ; and though it is small with rock-surfaces, these surfaces are great. In order to ascertain whether water vapour or solar radiation is the more effective, the author instituted observations at Luxor in order to obtain data to compare with those previously obtained by him in the damp atmosphere of Ceylon. The data obtained are given at length ; and from these it appears that negatively charged dust produces disturbances in the distribution : that in Luxor there is a well-marked maximum of potential gradient at 7 a.m., and a better marked one at 8 p.m., with intervening minima at 3 a.m. and at midday : that the average gradient is 128 volts per metre, and the maxima and minima may possibly be due to regular fluctuations in the distribution of the air-borne dust ; that in Ceylon the gradient remains appreciably the same during the twenty-four hours, with the exception of a slight rise at midday : that at Luxor the solar radiation is about 1½ times as great at midday and twice as great in the afternoon as it is at Vienna, Salzburg, or Wolfenbüttel, or, approximately, in Ceylon ; that the maxima and minima at night as well as by day tell against Hallwachs' photoelectric explanation of the variations ; that the absolute values of the potential gradient are also in disaccord with it, as also the considerations that Ceylon presents clear sky only in January and February ; and that at Luxor, with its minimum average of 128 volts per metre, the nature of the surface is much more favourable to photoelectric effect than that of the vegetation and open sea of Ceylon, so that the potential gradient ought to be less reduced in Ceylon than it is in Luxor, whereas there it is only 57 volts per metre. The photoelectric theory would also lead us to expect the potential gradient to be less steep at a height, whereas it is steeper. These considerations put the photoelectric effect down to the level of a subsidiary phenomenon ; but the data agree quantitatively with the water-vapour theory, allowing that the theoretical average of 150 volts per metre, with the average water-vapour pressure of 7·2 mm. at Luxor is correctly represented by the observed average of 128 volts per metre which is certainly somewhat too low on account of the disturbance produced by negatively charged dust. So far as observations have gone, the atmospheric electric currents alleged to be due to insolation, and to bring back to the earth the negative charges transferred to the atmosphere, are more in accord with the water-vapour theory than with the photoelectric theory pure and simple. The water vapour will itself carry the negative charges and restore them to the earth upon condensation. Braun's theory that the potential gradient falls with rising temperatures, is untenable : Ceylon (57 V per metre) has the same temperature as Luxor (128 V/*m*) ; and in Siberia the potential gradients remain the same between − 40° and + 30° C. A. D.

500. *Atmospheric Electricity during a Solar Total Eclipse.* **R. Ludwig.** (Akad. Wiss. Wien., S. ber. 108. pp. 436–444, 1899.)—Observations at Jeur, Deccan, Bombay Presidency, during the total eclipse of January 22, 1898; height 600 to 700 metres; apparatus, Exner's. The potential gradient fell from 150 to 120 volts per metre as totality was approaching, and went on falling to 89 for 30 minutes after it was over. The mean value of the potential gradient before the darkness was 131 volts per metre; water vapour, 8·3 mm.; temperature, 18·2° C.; potential gradient, calculated from Exner's water-vapour formula, 134 volts per metre. Potential gradient of Bombay (Exner) 64. The potential gradient clearly does not depend primarily on the temperature, and in order to support Elster and Geitel's photoelectric theory, Bombay being at a lower level should have had a higher potential gradient than Jeur, and during an eclipse the potential gradient should have risen. A. D.

501. *Balloon Measurements in Atmospheric Electricity.* **J. Tuma.** (Akad. Wiss. Wien., S. ber. 108. pp. 227–260, 1899.)—Observations and discussions. The leading features of the observations were that in some cases the potential gradients were reversed between particular altitudes, passing through zero values which in some instances were adhered to for some distances, in one case 600 metres, so that it seemed as if independently charged masses of air gave rise to the phenomenon; that the proportion of moisture in the air seemed to have nothing to do with this, and that even the presence of clouds does not determine any particular result; that the curve-lines obtained are sometimes very jerky; that positive potential gradients fall off with increase of altitude and therefore positive charges are accumulated in the atmosphere: and that there was no disturbing charge on the balloon itself. Cases have repeatedly occurred in which captive balloons have caught fire on being hauled down: possibly because they had acquired a high potential charge which there had not been time to dissipate, and which produced a spark at the valve. The danger might be obviated by throwing down a thin wire connected with the valve which would make an earth connection before the balloon reached ground. A. D.

502. *Dark Lightning-Flashes.* **W. J. S. Lockyer.** (Nature, 60. pp. 570–574, Oct. 12, 1899.)—The author here discusses the possibility and probability of the objective existence of dark flashes. He remarks at the outset that many *apparent* dark flashes as seen by the eye are probably due to retina fatigue, and so have only a subjective existence. Photography also may be deceptive, owing to the phenomenon of photographic reversal. A. W. Clayden, in 1899, put forward the following explanation of the apparent dark flashes shown by photography: If the lens be covered the moment after a flash has occurred, the developed image is always bright. If, however, after the flash has passed, the plate be exposed either to the continued action of a feeble diffused light or to the powerful glare arising from one or more subsequent flashes, then, on development, the image of the original flash will probably come out black. The present author then proceeds to test this explanation as applied to a number of very striking photographs exhibiting bright and dark flashes. He also took photographs of sparks from an induction coil with and without subsequent exposure to light reflected from burning magnesium. The examination of all these cases leads to an entire corroboration of Clayden's hypothesis. E. H. B.

503. *Cause of Dark Lightning and the Clayden Effect.* **R. W. Wood.** (Science, 10. pp. 717–721, Nov. 17, and Nature, 61. pp. 104–105, Nov. 30, 1899.)—A. W. Clayden has explained the presence of dark lightning-flashes in photographs by the peculiar photographic reversal now known as the Clayden effect. The present paper seeks the explanation of this effect, and finds it in the short duration of the initial flash. This renders the part of the plate acted upon less sensitive. Accordingly, the track of the flash in question comes out dark if, after the passage of the flash, the plate is further exposed to the continued action of light from ordinary sources. The paper establishes these points by a series of experiments which are briefly as follows: The Clayden effect was repeatedly obtained from electric sparks, but could not be obtained when the filament of an incandescent lamp was substituted for the spark. This showed that the spark had something necessary to the effect sought which the incandescent filament lacked. It was next shown that this quality was not intensity. It was subsequently shown that the photographic reversal under examination did not depend upon the wave-length of the radiation used. It then occurred to the experimenter that the time element might be vital to the problem. The light of the spark used lasted $\frac{1}{30000}$ of a second, and might differ in its action from a weaker light of longer duration. This was first tested by photographing (1) a single spark passing through a capillary tube with the lens wide open, and (2) four such sparks superimposed on the plate, but with the lens stopped down to one-quarter of its former aperture. The plate was then fogged in the usual manner, and on development the single discharge was reversed, but the composite one was not. To demonstrate conclusively that the time factor is the only one, the light from the crater of an arc lamp was focussed upon the point of coincidence of two slits. One of these was a radial slit in a disc driven at high speed, so as to give an exposure of $\frac{1}{55000}$ of a second. The anticipated reversal of the photographic image was obtained. E. H. B.

504. *Multiple Lightning-Flash.* **A. E. Kennelly.** (Elect. World and Engineer, 34. pp. 651–652, Oct. 28, 1899.)—This paper illustrates and describes the lightning-flash photograph, in which fourteen distinct bands are discernible. The photograph was taken by J. M. Justice, at Philadelphia, on August 10, 1899. E. H. B.

505. *Multiple and Dark Lightning-Flashes.* **E. Thomson.** (Elect. World and Engineer, 34. p. 738, Nov. 11, 1899.)—The author dismisses dark lightning as a myth due to contrast effects when seen by the eye, and, when photographed, to peculiarities of the photographic plate sensitiveness, now cleared up by Clayden's experiments. The phenomenon of multiple lightning is attributed to the transfer by wind of the streak of hot air through which a succession of discharges is passing. E. H. B.

506. *Spark Potential.* **A. Orgler.** (Ann. d. Physik, 1. 1. pp. 159–174, Jan., 1900.)—The object of the author's work was the definition of the spark potential in gases by one or more constants which are solely dependent upon the substance through which the discharge takes place, and not, like the electric strength, upon the width of gap and the pressure. Paschen's rule that a constancy of the product Pd of pressure and width of gap means a constant discharge potential, was very approximately confirmed at higher differences of potential, but not at lower ones. A quantity which is really characteristic

of the various gases is obtained by making the spark-gap infinitely small. Then there is still a finite difference of potential required to bridge it. In other words, the gap has an infinite resistance. The author defines as "specific electric strength" the ratio of the difference of potential required to perforate the gas to that required to perforate air under the same conditions. For hydrogen this ratio is 0·563, for CO_2 and oxygen 0·888, and for nitrogen 1·050. E. E. F.

507. *Polarisation of Dielectrics.* **H. Pellat.** (Annal. Chim. Phys. 18. pp. 150–181, Oct., 1899.)—In this paper the question is considered of the gradual absorption of electricity by condensers and of their residual charges.

Experiments were made to prove that this is a true dielectric polarisation independent of conduction, by the plan of splitting a dielectric sheet subjected to electric stress into two sheets, and then showing that on each of these sheets the total charge is zero, though all the time the sheets remain electrically strained.

Formulæ are obtained, somewhat similar to those adduced by Maxwell, by means of the following assumptions, and are shown to be not inconsistent with experiments made by Currie and also with some made by the author. The assumptions made are that the specific inductive capacity is an invariable quantity. That there is in addition an electric polarisation throughout the dielectric which increases with the time and owing to which there is a gradual increase in the apparent electrification of the surfaces. The final value of the polarisation for any given dielectric is proportional to the field. The rate of growth of the polarisation for a given dielectric is proportional to its deficiency at any moment from its final value.

Three constants thus should express the properties of a dielectric, but the author admits that it may be necessary to assume two or more superimposed polarisations in some cases, with a corresponding increase in the rate of growth constants. F. T. T.

508. *Resistance of Saline Solutions in Movement.* **A. Amerio.** (N. Cimento, 10. pp. 276–278, Oct., 1899.)—The author concludes that Bosi's experiments, though exact, are not conclusive, for the apparatus permitted alterations in the concentration. Hayward (and Hall, below) used low speeds as Bosi did, and got no positive alteration of the resistance of a solution; Edlund got positive results at high speeds. Bosi's experiments are not inconsistent with either of these results.

References :—Edlund, Ann. d. Phys. u. Chemie, v. 156. p. 251, 1875; Bosi, N. Cimento, 5. p. 249, 1897; Hall, Phys. Review, 7. p. 246, 1898. A. D.

509. *Conductivity of Dilute Amalgams.* **A. Larsen.** (Ann. d. Physik, 1. 1. pp. 123–131, Jan., 1900.)—A simple relation between concentration and electric conductivity is only exhibited by amalgams when they are very dilute. The author examined the conductivities of the amalgams of lead, zinc, cadmium, tin, and bismuth, at temperatures ranging from 0 to 100°, and compared them in every case with that of pure mercury at the same temperature. The general result obtained is that the relative conductivity increases with the temperature and with the concentration of the amalgam. This rule holds good up to the point of saturation of the amalgam, which occurs at a concentration of about 1·6 per cent. in lead amalgams, 2 per cent. in zinc amalgams, and about 5 per cent. in cadmium amalgams. All the results indicate that in dilute amalgams the metal is dissociated, and this dissociation, as generally in solutions, increases with the temperature. E. E. F.

510. *Conductivity of Copper.* (Engineering, 68. p. 804, Dec. 22, 1899.)—This is the report of a committee formed of representatives of the Institution of Electrical Engineers, the General Post Office, and the principal manufacturers of rubber insulated cables to determine a standard of conductivity of copper.

The committee resolved: (1) That Matthiessen's standard of 0·153858 standard ohms resistance for a wire 1 metre long, weighing 1 gramme at 60° F. be taken as the standard for hard drawn high conductivity commercial copper. (2) That hard drawn copper be defined as that which will not elongate more than 1 per cent. without fracture. (3) That Matthiessen's standard of 0·150822 standard ohms resistance for a wire 1 metre long, weighing 1 gramme at 60° F. be taken as the standard for annealed high conductivity commercial copper. (4) That copper be taken as weighing 555 lbs. per cubic foot at 60° F., which will give a specific gravity of 8·912. (5) That Messrs. Clarke, Forde, and Taylor's temperature coefficient, as published in their pamphlet, dated February 20, 1899, be adopted, and that an average coefficient of 0·00238 per degree Fahrenheit be adopted for commercial purposes. (6) That the resistance and weight of conductors be calculated from the actual length of the wires. (7) That a lay of twenty times the pitch diameter be taken as the standard for the calculation of tables. (8) That 2 per cent. variation of resistance or weight be allowed in all conductors. (9) That an allowance of 1 per cent. increased resistance, as calculated from the diameter, be allowed on all tinned copper between Nos. 22 and 12 gauges inclusive. W. G. R.

511. *Thermo-magnetic Transverse Effect in Bismuth.* **E. Yamaguchi.** (Ann. d. Physik, 1. 1. pp. 214-224, Jan. 1900.)—When a plate of bismuth is traversed by a current of heat and at the same time exposed to a magnetic field at right angles to its plane, an E.M.F. is generated in the plate in a direction normal to the heat current. If a man were to stand in the magnetic lines of force so that they proceeded from his feet to his head, and were to look in the direction of the heat current, the E.M.F. would be directed towards his right hand. This effect has been termed the thermo-magnetic transverse effect by its discoverers, Ettinghausen and Nernst. Symbolically, the effect is approximately governed by the equation—

$$q = -\beta \frac{\delta t}{\delta z} H Q_t,$$

where q is the E.M.F., β the distance between the terminals of the circuit, and Q_t a function of the temperature. Putting $HQ_t = m$, it is found that m is nearly proportional to the increase of resistance experienced by bismuth in the magnetic field. In his experiments on this subject the author finds that both these quantities increase very rapidly at the lowest temperatures, being doubled or trebled as the temperature falls from 30° to 120°. For a full elucidation a better knowledge of the thermal conductivity of bismuth is essential. E. E. F.

512. *Measurement of Weak Self-Inductions.* **A. Blondel.** (Écl. Électr. 21. pp. 138–141, Oct. 28, 1899. Paper read before the Assoc. française, Boulogne.)—Most of the methods in use are defective in that they require a Wheatstone bridge, the coils of which themselves have both self-induction and capacity. The author utilises the property of torsion electrodynamometers, that if the fixed and the movable coils are respectively traversed by currents similar but differing in phase by $\frac{1}{4}$ period, the electrodynamic couple is zero. He makes the two coils rectangular, one with its longer and the other with its shorter

sides vertical. *Method* 1.—Put the one coil in series with the self-induction to be measured; the other in series with an adjustable standard self-induction; supply the respective coils with currents differing 90° in phase; adjust the standard until there is no deflection in the electrodynamometer and observe the value L_1; the time constants of the two circuits are then equal. Then take out the self-induction which is being measured, and again adjust until there is no deflection in the electrodynamometer: the adjustable self-induction now stands at L_2. Let R be the resistance of each of the coils of the electrodynamometer, L the self-induction of each—there is no mutual induction—r the resistance of the coil under investigation, r' that of the standard of self-inductance. Then—

$$\frac{L+L_1}{R+r'}=\frac{L+x}{R+r};\quad \frac{L+L_2}{R+r'}=\frac{L}{R};$$

whence the required self-induction of the coil under examination is—

$$\frac{R(r+r')L_2+(R+r)r'L_1}{r'(R+r')}$$

Method 2.—Instead of using an adjustable standard of self-induction, put known resistances in one or other circuit to equalise the time-constants; but in that case the resistances must be dead and be able to carry $\frac{1}{10}$ ampere, so as to keep down the impedance in the electrodynamometer. Put the coil under investigation in one of the circuits: if (using the same symbols as before) $\frac{x}{r}>\frac{L}{R}$, put an additional resistance R′ in the same circuit; if it be less, put this in the other circuit. When, in the former case, the apparatus is brought to zero by adjusting R′, we have—

$$\frac{L+x}{R+r+R'}=\frac{L}{R'},$$

whence—

$$x=L\frac{r+R'}{R},$$

and if L be known, x is easily determined. In the latter case

$$\frac{L+x}{R+r}=\frac{L}{R+R'},$$

whence—

$$x=L\frac{r-R'}{R+R'}$$

If the two currents are supplied under equal electromotive forces, the deformation of the curves are similar, and the currents are similar. A. D.

513. *Electric Units.* **A. Blondel.** (Écl. Électr. 21. pp. 7–11, Oct. 7, 1899. Paper read before the Assoc. Franç. at Boulogne.)—Attention is drawn to the grave practical inconveniences arising from the coexistence of the c.g.s. and the practical system of units. The practical units bear varied relations to the c.g.s. units, as this conspectus shows:—

	Multiples of C.G.S. Units.
Microfarad	10^{-15}
Micro-ampere, micro-coulomb	10^{-7}
Microvolt	10^{2}
Watt, Joule	10^{7}
Quadrant, Ohm, Hectowatt, Henry	10^{9}
Megohm	10^{15} &c.

The author, after combating it, now falls in with the suggestion of the American Institution of Electrical Engineers that the systems of units should be based upon the c.g.s. units, and extends it to electrical quantities as well as to magnetic. His present scheme is shown in the following table, in which sufficient terms are entered to show in what manner the various prefixes are used :—

	NAMES OF UNITS.								
	Submultiples.				C.G.S. Units.	Multiples.			
	10^{-15}	10^{-9}	10^{-6}	10^{-3}		10^{3}	10^{6}	10^{9}	10^{15}
Current Strength	Cathogalva	Hypogalva	Microgalva	Milligalva	Galva	Kilogalva	Megagalva	Hypergalva	Anogalva
Potential	...	...	...	...	Frank	...	...	...	...
Resistance	...	...	...	...	Thom	Kilothom	...	Hyperthom	Anothom
Quantity	...	Hypopoisson	...	...	Poisson	...	...	...	...
Power	...	...	...	...	Max	...	...	...	...
Energy	...	...	...	...	Erg	...	Megerg	Hypererg	...
Inductance	...	...	...	...	Helm	...	...	...	...
Capacity	Catharag	...	...	...	Arag	...	...	...	...

Under this system of nomenclature we would say 11 hyperfranks instead of 110 volts, 10 galvas instead of 100 amperes, and we would say hyperthoms instead of ohms and hypermaxes instead of hectowatts. Medical men, instead of 1 to 200 milliamperes, would use currents of from 0·1 to 20 milligalvas. Perhaps the public would find hyperfrank and hyperthom to be rather long words : but some such words would have to be used. The French Association (physical section) approved in principle of the suggestion. A. D.

514. *Contact Electricity.* **F. S. Spiers.** (Phil. Mag. 49 pp. 70–90, Jan., 1900. Paper read before the Physical Society.)—The object of this investigation was to determine the part which the surrounding medium plays in the contact force of metals, special regard being paid to the films of air condensed on the plates. The experiments were carried out in vacuo. The apparatus first employed was constructed on the principle used by Ayrton and Perry in their researches. This, however, was found to be difficult to work with, and was therefore replaced by apparatus in which the plates were magnetically separated for each measurement, the P.D. being measured by Kelvin's compensation method. Heating in high vacua of air merely gave results due to oxidation. The air was therefore replaced by hydrogen, the couple being platinum-aluminium. But the author found that "even in a high vacuum of pure dry hydrogen at the minute pressure of $\frac{1}{10000}$ mm. of mercury, and after four washings in that gas, there is still sufficient oxygen present to completely oxidise the surface of an aluminium plate, if it be only brought to a sufficiently high temperature." It was therefore decided to remove the air films chemically. For this purpose a platinum-iron couple was used. The glass containing-tube was washed out four times with hydrogen, and then heated a number of times to about 800° C. A steady value was not easily obtained, but the final result was that the P.D. fell from + 0·37 to — 0·60, which the author regards as the true value of the volta effect between iron and platinum in an atmosphere of hydrogen. On admitting a small quantity of air the value slowly varied towards a positive value, and on heating to accelerate the change it rose to + 0·22. Further heating reduced this figure to zero, owing to oxidation. W. R. C.

515. *Hissing of the Arc.* **Mrs. Ayrton.** (Instit. Elect. Engin., Journ. 28. pp. 400–430. Discussion 431–450, 1899.)—A change taking place in the electric arc may manifest itself in three ways: (1) By emitting various sounds or by becoming silent; (2) By changes in its electrical measurements; and (3) By an alteration in the appearance of the crater, the arc, and the carbons. The two sounds of the arc which possess significance are the *hum* and the *hiss*. The humming sound is heard when the arc is just on the point of hissing or ceasing to hiss, although it is possible for an arc to jump suddenly from the silent to the hissing state, or *vice versâ*. The paper deals with the arc in this transition stage, viz., from silence to humming and from humming to hissing. No difference in the electrical measurements is noticed whether the arc is silent or humming. The hissing of the arc, which is accompanied by considerable changes, is dealt with more particularly.

Sets of curves are given for direct-current open arcs, showing the variation of the P.D. (between the carbons), with the current strength, for various constant lengths of arc, both silent and hissing. These curves show that:—

1. A silent arc of constant length may be made to hiss by increasing the current strength.

2. A silent arc with constant current may be made to hiss by shortening the arc.

3. When hissing commences the P.D. falls suddenly about 10 volts, and a sudden rise in current also takes place.

4. The largest current that will maintain a silent arc is greater the longer the arc.

5. For the hissing arc, the P.D. is constant for a certain length of arc, whatever the value of the current.

The author proves from the curves of actual experiments that for each pair of carbons the current that will sustain a normal silent arc has a maximum value, and that any current greater than this will make the arc hiss, however long it may be. It is also shown that with the hissing, as with the silent arc, a straight line law connects the P.D. between the carbons with the length of the arc; the difference between the law for silent and for hissing arcs being that, with silent arcs the law holds only for constant currents or for currents at the hissing point, whereas with hissing arcs it holds whatever the current may be, since the P.D. between the carbons of a hissing arc is constant for a certain length of arc, irrespective of the current strength. Also from these curves it is shown that the longer the arc the less does the P.D. between the carbons diminish when it changes from silence to hissing.

Experiments were made on the distribution of the fall of pressure in the arc itself, Luggin's results of 1889 being confirmed, viz., that the maximum part of the diminution of P.D. is between the positive carbon and the arc itself. In a hissing arc about two-thirds of the total diminution is accounted for at this point, the remaining third appearing to be due to a lowering of the resistance of the arc itself. The author found that the value of the smallest hissing current depended on the circuit outside the arc, or the sudden increase of current when hissing begins equals the product of the sudden diminution of the P.D. into the conductance of the circuit outside the arc.

The electrical measurements of hissing arcs being dealt with, the author next considers the appearance of the crater, arc, and carbons.

The different changes in appearance are described, from that of a low-current silent arc in which the current is gradually increased to that of a humming and finally a hissing arc. Illustrations are given showing the general shape of the carbons and the distribution of colours in the arc at

these different stages. The most important change in the arc is on the commencement of hissing, when the negative begins to form a "mushroom" at its tip and the crater on the positive more than covers the tip of the carbon. The positive carbon changes to such an extent with different conditions of burning, that it is quite possible to state the conditions under which a normal arc has burnt from the appearance of the positive carbon. The hissing of the arc is caused by air coming in contact with the crater, and is due to the carbon burning instead of volatilising. A silent arc is changed at once into a hissing arc when the flame of the arc leaves the end of the positive carbon and burns on the vertical sides, the air being able to enter the crater itself, thus producing the hissing by causing a part of the heated carbon to burn. This conclusion was arrived at after many experiments. With perfectly enclosed arcs no hissing could be produced; open arcs were made to hiss by having gases introduced into the crater of the arc through a tubular positive carbon. With air or oxygen thus admitted into an open silent arc all the peculiarities of a hissing arc were produced, and also, to a less extent, with hydrogen. With carbon-dioxide or nitrogen no hissing was produced. The same gases, when introduced into the crater of an enclosed arc, produced similar results, with the exception of hydrogen, which produced no hissing. With both open and enclosed arcs no hissing was produced by any of the gases when introduced through the negative carbon gently; but when forced through, hissing was produced and the arc blown out.

Another reason for believing that hissing is caused by access of air to the crater is that the green colour, seen on the outside only of a silent arc, is to be found inside in the case of a hissing arc.

The reading of the paper was followed by a lengthy discussion. E. D. P.

516. *Electrical Instruments.* **W. E. Ayrton.** (Instit. Civ. Engin., Proc. 138. pp. 481–485, Oct., 1899; also Engineer, 87. p. 611.)—The five most important metals employed in the construction of electrical instruments are copper, iron, steel, phosphor-bronze, and some alloy of high resistivity.

For use in central stations or wherever there is a comparatively strong magnetic field, instruments should be used whose action depends upon the motion of a coil in a strong magnetic field so as to eliminate as nearly as possible errors due to variation of field from external causes. Direct reading ohm-meters, measuring up to 50 meghoms, can now be obtained; but apparatus is also needed for enabling the insulation of an electric light cable to be tested where laid. At present cable is often supplied which, although possessing only a fraction of the specified insulation, is accepted because suitable testing apparatus can be used only in a laboratory. W. G. R.

517. *Dynamo-Static Machine.* **E. Thomson.** (Mech. Eng. 4. p. 682, Nov. 4, 1899. Abstract of a Lecture delivered before the New York Electrical Society.)—This machine consists partly of a motor dynamo, such as is obtained by taking an ordinary continuous current motor and tapping the winding so as to obtain alternating currents. To effect this, two of the commutator segments are connected to a pair of insulated metal rings on the shaft. The alternating current brushes are connected to the terminals of the primary winding of a step-up transformer. Driven by the shaft of the machine is a frame of insulating material, having at one side a pair of metal strips which periodically connect the high potential secondary terminals of the step-up transformer to the plus and minus coatings of a

set of condensers in parallel. These connections, to avoid noise and friction, are made without actual contact; that is, over a small spark-gap. The revolving frame is so adjusted that the charging shall be completed only at the tops of the waves, and then a higher potential is available for charge. The revolving frame carrying the charging strips also carries a set of series connectors, whereby, after the charging strips have withdrawn from proximity to the stationary contacts led from the condenser plates, these contacts are connected in series, and the terminals discharge across a wide air-gap. The length of spark is governed by the number of condenser plates and the potential of the charging current.

The author has added a further attachment whereby Leyden jar batteries may be charged, and with this attachment the machine may be used to excite the sectors of large influence machines in all states of the weather. This attachment consists of a revolving connector covering a wide gap between the terminals or end condenser coatings and a stationary insulating ball or conductor. This connector itself, consisting of a pair of balls or rounded surfaces connected by a wire, is insulated and synchronously bridges the gap of several inches between the end condenser terminal and the insulated ball. The time of making this connection coincides with that of the series connection made by the revolving frame. The insulated ball is thus synchronously charged, while the opposite terminal of the apparatus may be put to earth. The ball may be made either positive or negative by changing the alternating current connections from the collector rings to the primary of the step-up transformer. A Leyden jar battery may be charged by connecting its interior coating with the insulated ball, and its exterior to earth, or to the opposite terminal of the apparatus; and from the charged jar condenser a string, dipped in very weak acid, or rubbed in graphite, may be made the means for conveying the jar charge slowly to a prime conductor for weak or thin sparks, whereby the effects of a static machine may be closely reproduced. W. G. R.

518. *Alternate-Current Curve-Tracer.* **W. Peukert.** (Elektrotechn. Ztschr. 20. pp. 622–623, Aug. 31, 1899.)—The Joubert contact-disc is not mounted directly on the spindle of the alternator, but is connected to it by means of toothed-wheel gearing, the numbers of teeth in the consecutive wheels (of which there are four) being so chosen that the contact-disc revolves at a somewhat higher speed than the alternator. The arrangement is therefore equivalent to a device (such as that due to Barr, Burnie, and Rodgers) for slowly moving the instantaneous contact-brush, and thus enabling the curve to be traced out in a very short time. A. H.

519. *Current Produced in an Induction Coil by a Parabolic Wave of E.M.F.* **A. Russell.** (Elect. Rev. 45. pp. 744-745, Nov. 10, 1899.)—In this paper the author gives theoretical proofs of the following results:—

(1) If we have a sine wave and a parabolic wave of E.M.F. giving the same effective volts, then the parabolic wave is more flattened than the sine wave. The maximum ordinate of the sine wave is about 3 per cent. higher than the maximum ordinates of the parabola. (2) The ratio of the area of the parabola to the area of the sine curve is 1·014. This also gives the ratio of the maximum values of the choking coil currents. (3) If both waves be applied separately to a non-inductive resistance, the effective currents produced will be equal. If they be applied to an inductive coil

then the current produced by the sine wave will be the greater. If they be applied to a condenser the current produced by the parabolic wave will be the greater. (4) For an inductive coil the power factor is always greater for the sine curve, and the impedance and reactance are both greater for the parabola. (5) The impedance for the parabolic wave is not of the form $\sqrt{R^2 + p^2L^2}$ where p is some function of the frequency. In this case also the angle whose cosine equals the power factor is not in general the angle of time lag of the current curve behind the E.M.F. curve. W. G. R.

520. *Theory of the Power Factor.* **A. Russell.** (Electrician, 44. pp. 49–50, Nov. 3, and 72–73, Nov. 10, 1899.)—The power factor is defined as—

$$\frac{\int_0^T ei\,dt}{\left(\int_0^T e^2dt \int_0^T i^2dt\right)^{\frac{1}{2}}}$$

where e and i denote the instantaneous values of the volts and amperes, t is the time in seconds, and T the period of the alternating current. The author shows that the power factor is not necessarily unity if the values of e and i are always simultaneously zero, but that its value depends upon their wave forms. Taking the current wave to be a sine curve, numerical values of the power factor are calculated for various forms of the E.M.F. wave; these results are tabulated thus :—

Wave Form of E.M.F. curve.	Maximum value of e.	Height of Centre of Gravity of Wave.	Power Factor $\cos\phi$, with I $\sin pt$ for Current.	ϕ in Degrees.	Power Factor with I $\sin(pt-\alpha)$ for Current.
Rectangle.....	V	0·5 V	0·9003	25·8	0·9003 $\cos\alpha$
Parabola	1·370 V	0·5476 V	0·9995	2·2	0·9995 $\cos\alpha$
Sine Curve	1·414 V	0·5552 V	1·0000	0	$\cos\alpha$
Triangle	1·732 V	0·5773 V	0·9928	6·75	0·9928 $\cos\alpha$
Inverted Parabola	2·236 V	0·6708 V	0·9322	21·2	0·9322 $\cos\alpha$
Inverted Cubics ...	2·646 V	0·7560 V	0·8628	30·4	0·8628 $\cos\alpha$

Thus if $\cos\phi$ is the power factor when α is zero, $\cos\phi\cos\alpha$ is its value for any given value of α. The paper is summarised as follows :—

1. If the power factor of a circuit is unity, then the potential difference and current waves are similar curves, *i.e.*, the value of the volts divided by the value of the amperes at any instant is constant.

2. If the potential difference wave be flat and the current wave peaky, or *vice versâ*, then the power factor may be small, even if there be no time lag between them.

3. It is convenient for graphical purposes to define the phase difference

between two periodic functions, $f(t)$ and $F(t)$, as an angle ϕ given by the equation—

$$\cos\phi = \frac{\int_0^T f(t)F(t)dt}{\left(\int_0^T \{f(t)\}^2 dt \int_0^T \{F(t)\}^2 dt\right)^{\frac{1}{2}}}$$

4. If either the current or potential difference wave is a sine curve, and the other is a symmetrical curve, then the power factor equals $\cos\phi \cos\alpha$, where $\cos\phi$ is the power factor between them when there is no time lag and α is the angle of time lag. W. G. R.

521. *Half-Ring Electromagnet.* **H. du Bois.** (Ann. d. Physik, 1. 1. pp. 199–206, Jan., 1900.)—The ring-electromagnet described by the author yields a field of some 40,000 units over a space of several millimetres. By using micromagnetic appliances with dimensions of the order of 0·1 mm., the values 51,600 for H and 74,200 for B were obtained. But the whole apparatus weighs 5 cwt. and uses 5 kw. The author has therefore constructed a lighter type, by reducing the linear dimensions 20 per cent. and cutting off the lower third of the ring, which is replaced by a bedplate. Excitation is made by eight magnetising coils, with an interval between the highest and the second on each side, which allows the observer to remove two plugs running along the magnetic axis, and thus expose the axis for polarisation and other experiments, The power consumed in this type is 1·44 kw. In another type, which is still smaller, the power consumed is 256 volts, the weight is 25 kgm., the height of the axis above the table is 25 cm., the number of turns 2,000, the resistance 4 ohms, and the inductance 60 henries. The efficiency of these half-ring electromagnets is, if anything, greater than that of the whole-ring instrument, the field furnished by the heavier type being 36,000 units, and by the lighter type 20,000 units. E. E. F.

522. *Magnetic Properties of the Elements.* **J. Koenigsberger.** (Ann. d. Physik, 1. 1. pp. 175–177, Jan., 1900.)—The author considers it as definitely proved that a compound formed of two diamagnetic substances may be itself paramagnetic, and instances the cases of cuprous sulphide, selenide, and phosphide. A connection can be traced between atomic magnetism and atomic volume, but this connection is complicated by the anomalous position of tin. The author regards the magnetic susceptibility of water as undetermined as yet, and thus throws a doubt on all data obtained from aqueous solutions. Wire-drawing has a well-marked effect upon the magnetic susceptibility of a metal in certain directions. E. E. F.

523. *Molecular Magnetic Susceptibilities.* **O. Liebknecht** and **A. P. Wills.** (Ann. d. Physik, 1. 1. pp. 178–188, Jan., 1900.) **H. du Bois** and **O. Liebknecht.** (Ann. d. Physik, 1. 1. pp. 189–198, Jan., 1900.)—The first paper deals with the magnetic susceptibilities of paramagnetic salts of the iron group, including haloids, sulphates, nitrates, and alums, of chromium, manganese, iron, cobalt, nickel, and copper. The susceptibilities show an increase from chromium to manganese, and a subsequent gradual fall from ferric iron to cobalt, nickel, and copper. Jäger and Meyer's series of atomic magnetisms 6 : 5 : 4 : 2 for Mn, Fe, Co, Ni, respectively is only very roughly

confirmed, but some of the discrepancies may possibly be due to the nickel salts containing some cobalt.

In the second paper the molecular susceptibilities of several rare earths are studied, including those of yttrium, cerium, praseodymium, neodymium, samarium, gadolinium, erbium, and ytterbium, all of Swedish preparation. In contradistinction to the iron group of elements, there is here a gradual rise of susceptibilities from the beginning of the series to erbium, and a sudden fall to ytterbium, the two last values being 0·03668 and 0·00711 respectively. Among important substances yet to be tested are titanium, vanadium, and perhaps thorium ; and molybdenum, tungsten, and uranium in the iron group. The difficulty encountered in these metals is that they do not form paramagnetic compounds. The authors consider the determination of susceptibilities in the wet way as both simple and accurate. E. E. F.

524. *Magnetic After-effect.* **L. R. Laird.** (Ann. d. Physik, 1. 1. pp. 207–213, Jan., 1900.)—In experiments on magnetic viscosity a doubt attaches to the initial or instantaneous value of the magnetisation. This doubt is eliminated in the method of Martens, in which horizontal discs are made to rotate in a magnetic field. Their magnetic moment is found to be independent of the speed of rotation within wide limits, and is therefore identical with the instantaneous value itself. The after-effect is then determined by the increase experienced when the disc stops. To study the increase of moment with the time the author used an astatic system with one of its needles placed near the edge of the disc, and in the plane of the latter. The ratio of the initial to the final intensity of magnetisation was found to be 0·872 in the disc used, which was of rolled iron, 0·062 cm. thick, 4·5 cm. in diameter, and repeatedly annealed. To follow the course of the after-effect in time a photographic method was used. The effect was completed in twelve seconds. E. E. F.

525. *Plane Magnetisation of Pyrrhotine.* **P. Weiss.** (Journ. de Physique, 8. pp. 542–544, Oct., 1899.)—This mineral, Fe_7S_8, can be magnetised only in one plane, and in a direction at right angles to this plane there can be no magnetisation. Discussion of experimental methods. This curious property may throw some light on the behaviour of magnetic metals, considered as crystalline substances. (See also 1899, Abstract No. 713.) A. D.

526. *Altitude and Terrestrial Magnetic Force.* **A. Pochettino.** (Accad. Lincei Atti, 8. pp. 204–212, Oct. 15, 1899.)—The author finds (at Gran Sasso, Italy) that the gradient of H is 0·0005 c.g.s. units per thousand metres of ascent. A. D.

REFERENCES.

527. *Electrothermal Relations.* **F. Kohlrausch.** (Ann. d. Physik, 1. 1. pp. 132–158, Jan., 1900.)—A paper similar to that referred to in Abstract No. 136 (1900). E. E. F.

528. *Thermoelectricity.* **L. Holborn** and **A. Day.** (Preuss. Akad. Wiss. Berlin, S. ber., 36. pp. 691–695, 1899.)—Measurements were made of the thermoelectric constants of the platinum metals and gold and silver over a large range of temperature. The hot junctions were raised to 1,000° and in some cases to 1,300°. The results are given in a table. Observations were also made at lower temperatures down to −185 . J. J. S.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

529. *Adsorption.* **J. G. C. Vriens.** (Zeitschr. Phys. Chem. 31. pp. 230–234, Dec. 22, 1899.)—The adsorption taking place when a centinormal solution of nitric acid is passed through a number of filter papers is measured by determining the molecular conductivity of the liquid before and after filtration. The author concludes that the diminution of concentration is proportional to the number of filters employed. T. H. P.

530. *Liquid Air.* **J. Dewar.** (Roy. Instit., Proc. 15. pp. 815–829, Aug., 1899.)—Liquid air assumes the spheroidal state when poured into a silver basin heated to redness. When a gas is caused to condense in a bulb, cooled by liquid air boiling in a vacuum, an admixture of an uncondensable gas which is not readily soluble in the condensed liquid may be detected. One part of hydrogen in 1,000 of air can just be detected in this way. Helium is readily separated from the gas (mainly nitrogen) evolved from the King's Well at Bath by this method.

At the temperature of liquid air argon is more opaque to Röntgen rays than oxygen, nitrogen, or sodium; it is on a level with potassium, chlorine, phosphorus, aluminium, and sulphur. This suggests that its atomic weight is comparable with those of the latter group of elements.

A large number of comparisons of the times in which equal quantities of liquid air evaporate from different vacuum test tubes were made. When the annular space is (1) filled with air, (2) vacuous, (3) vacuous and silvered inside, the times of evaporation are approximately as 1 : 5 : 30. When the annular space is (1) vacuous, (2) vacuous and filled with lampblack, the times are as 1 : 4. Other powders have a similar (usually smaller) effect. When air is admitted, however, the tubes containing the powders are less efficient than those without them.

At the temperature of liquid air a photographic film was six times less sensitive to ordinary and Röntgen radiation and sixteen times less sensitive to ultra-violet light than at the ordinary temperature. T. E.

531. *Properties of Iron.* **Galy-Aché.** (Comptes Rendus, 129. pp. 1230–1232, Dec. 26, 1899.)—To explain the peculiar phenomena of the tempering of steel, Osmond and Werth put forward the hypothesis of the existence of two allotropic forms of iron : α-iron, stable at ordinary temperatures, and β-iron, stable at high temperatures. The author describes some experiments which go to confirm this view. Some of them recall the familiar facts of recalescence, while others show that recalescence is accompanied by a certain retardation in the compression, which depends greatly upon the manner in which the iron is cooled down from temperatures above 850°. The iron experimented upon was nearly pure and quite free from carbon, though it contained traces of phosphorus. If this iron is subjected to a pressure of 18 kg. per square mm. it shows a certain permanent compression. When released and then subjected to the same pressure, no further compression sets in until the previous maximum pressure is attained. When the release has lasted several hours, the specimen will support a much higher pressure than that previously attained without giving way. Sudden cooling after heating to 850° eliminates the properties described. E. E. F.

532. *Alloys of Iron and Nickel.* **F. Osmond.** (Instit. Civ. Engin., Proc. 138. pp. 312–327, Oct., 1899.)—The positions of the critical points Ar_1, Ar_2, Ar_3 are observed both by heating and by cooling alloys of nickel and iron containing up to about 50 per cent. of nickel. The critical points are depressed by the addition of nickel, but the changes to which these points are due are not reversible in nickel steels containing less than 25 per cent. of nickel, the changes occurring at a higher temperature during heating than during cooling. The divergence increases with the percentage of nickel. With 3·82 per cent. of nickel the points Ar_3 and Ar_2 (cooling curve) merge into one, and, when the percentage of nickel has reached about 15, Ar_1 either disappears or merges into the point $Ar_{3\text{-}2}$. The heating curve has only one critical point between 7·65 and 24·5 per cent. of nickel. Steels containing less nickel have two critical points, one corresponding to Ac_3, the other to Ac_1 and Ac_2. Alloys with 29·07 and 49·65 per cent. of nickel showed no critical point.

The temperatures at which the magnetism of the alloys appears and disappears are determined (see 1899, Abstract 1203); these temperatures coincide with the points Ar_2 and Ac_2 respectively.

The total magnetism decreases as the percentage of nickel increases, becoming zero at about 29 per cent. of nickel; it then increases again. The residual magnetism, starting at zero in pure iron, increases to a maximum at 15·48 per cent. of nickel, and then decreases to zero at 29 per cent. of nickel. For the alloys containing more than 29 per cent. of nickel it is very small. The alloys with 14 to 15 per cent. of nickel remain hard after cooling from temperatures above the point $Ac_{3\text{-}2}$ (610° to 620°), but are softened by heating to temperatures below this. The permanent magnetism of such alloys is shown to increase with the hardness, and to afford a ready method of following the effects of the thermal treatment.

The microstructure of nickel steels is investigated. (See 1898, Abstract No. 1071.) T. E.

533. *Heat of Formation of Alloys.* (Electrician, 43. pp. 883–884, Oct. 13, 1899. Report of Brit. Assoc. Committee.)—Experiments were made on 22 different alloys of zinc and copper. To obtain the heat of formation, the heat of solution of the alloy was found and compared with the heat of solution of the constituents. The differences indicate that the heat of formation is at first negative, and reaches a maximum at 16 per cent. of copper. With greater percentages of copper it becomes positive, reaching a maximum at 38 per cent. of copper. Beyond this point it again grows less, being almost zero at 90 per cent. of copper. Curves and a table of results are given.

W. R. C.

534. *Heat of Dilution of Solutions.* **O. Tumlirz.** (Akad. Wiss. Wien., S. ber. 108. pp. 323–340, 1899.)—Thomsen's theory is inadequate. The author works out the subject from the point of view of the mathematical theory of attraction, and finds the energy of a mixture of two liquids—A and B—to undergo three alterations upon admixture. (1) The liquid A assumes a new volume V′, that of the mixture, and its own energy varies accordingly. (2) The same for liquid B. (3) The energy due to the mutual attractions between A and B has to be accounted for. The result is the establishment of a formula—

$$W = \frac{an + be + cen}{V'},$$

where W is the energy (heat) liberated or absorbed, a, b, and c are constants, n is the ratio between the masses of the diluent and the diluted liquid, e is the difference between the original volumes and the final volume, and V′ the final volume. In the case of sulphuric acid and water, $a = 159{\cdot}40$, $b = 222{\cdot}55$, and $c = 73{\cdot}84$. In the case of acetic acid, $a = -44{\cdot}00$, $b = 122$, $c = 505$; so that on adding water progressively to acetic acid there is first cooling and then the evolution of heat. A. D.

535. *Ozonised Water.* **E. Andréoli.** (Électricien, 18. pp. 302–304, Nov. 4, 1899.)—The author first discusses the writings of various authorities on the solubility of ozone in water or solutions of mineral acids and salts. He points out that solution is best effected by bubbling ozone in a finely divided stream into the liquid (see 1889, Abstract No. 1949). The solubility under the best circumstances is slight, and in no case does the solution remain, as the amount of ozone present becomes rapidly less and then disappears, leaving no trace either when analysed or to the nose.

The same is found when dry ozone is kept in a closed glass receptacle. The value of ozone as a bactericide in the case of tuberculosis is pointed out, but a warning is given against a number of high-priced quack preparations which are said to contain ozone, but which are merely very dilute solutions of alkaline hypochlorites. The discovery of a real means of preserving ozone in a form in which it could be utilised as a medicine is pointed out as being probably of great value. J. L. F. V.

536. *Explosion of Potassium Chlorate.* **Berthelot.** (Comptes Rendus, 129. pp. 926–929, Dec. 4, 1899.)—Potassium chlorate is an endothermic compound, as indicated by the equation $KClO_3 = KCl + 3O + 11{\cdot}9$ Cal., but it is not usually classed among explosive substances. If, however, the salt is very suddenly heated to a temperature above that at which it begins to decompose, as by dropping a small portion of the fused salt into a red-hot glass tube, a sharp, though slightly prolonged, detonation is observed. Picric acid, as the author has previously shown, behaves in a similar manner, and analogous phenomena are observed with acetylene. In each case the velocity of combination or decomposition continues to increase, provided the conditions are such that the rise in temperature is not checked by dissociation, change of physical state, &c. The detonation of potassium chlorate is more violent when combustible substances are also present, as was the case in the recent explosion at St. Helens. N. L.

537. *Action of the Medium on Velocity of Reaction.* **A. de Hemptinne.** (Zeitschr. Phys. Chem. 31. pp. 35–41, Dec. 22, 1899.)—The author determines velocity constants for the saponification of methyl acetate by mixtures of hydrochloric acid and acetone of varying composition, the electrical conductivity of the different mixtures being also determined. As the proportion of hydrochloric acid used decreases, the velocity constant and the conductivity also decrease, but not to the same degree, the ratio of speed to conductivity showing a considerable increase. Thus, besides the ionic action, the solvent exerts an action on the saponification velocity which in the case of acetone is catalytic, acetone having no chemical action either on methyl acetate or its saponification products. Using mixtures of glycerine and hydrochloric acid and of glycerine and sulphuric acid, no constant numbers are obtained for the saponification velocity of methyl acetate; the action of the glycerine in promoting the splitting up of methyl acetate depends on the slight affinity it possesses for acetic acid. T. H. P.

538. *Velocity of Crystallisation and of Change in Heterogeneous Systems.* **M. Wildermann.** (Zeitschr. Phys. Chem. 30. pp. 341–382, Nov. 1, 1899.)—Details of the experiments from which the equation $dt/dz = C(t_0 - t)(t - t_1 + K)$ [Abstract 1393, 1899] is obtained are given. The application of this equation to chemical and physical change in heterogeneous systems is discussed. T. E.

539. *Solid Solutions and Isomorphous Mixtures.* **G. Bruni.** (Accad. Lincei Atti, 8. pp. 212–219, Oct. 15, 1899.)—Isomorphous mixtures are in all respects merely special cases of solid mixtures. Conclusions to the contrary, by Küster, Bodländer, and others are discussed. A. D.

540. *Coagulative Power of Electrolytes.* **W. C. D. Whetham.** (Phil. Mag. 48. pp. 474–477, Nov., 1899.)—Electrolytes possess the property of coagulating solutions of colloids such as albumen and As_2S_3, and their relative coagulative powers depend on the valency of the metallic ion. The coagulative power of a substance may be taken to be inversely proportional to the number of gramme-equivalents which must be added to a definite solution of the colloid in order that immediate coagulation should follow. Linder and Picton found equi-coagulative solutions of sulphates of mono , di-, and tri-valent ions, acting on arsenious sulphide, to bear the relative concentrations 930, 26, 0·9, so that the relative coagulative powers would be in the ratios 1 : 35 : 1023. For chlorides Schultze found similar ratios 1 : 30 : 1650. Suppose that, in order to cause coagulation, a certain minimum electrical charge has to be brought within reach of a colloidal group, and that such conjunctions must occur with a certain minimum frequency throughout the solution. To bring up such equal charges we must have the conjunction of $2n$ triads, $3n$ dyads, or $6n$ monads. The chance of an ion being within reach of a fixed point is a fraction, Ac, where A is a constant and c the concentration ; that of two ions is $(Ac)^2$; that of three is $(Ac)^3$; that of n is $(Ac)^n$. For equi-coagulative powers the frequency with which the necessary conjunctions occur must be the same in each solution ; and for triads, dyads, and monads respectively $A^{3n}c_3^{2n} = A^{3n}c_2^{3n} = A^{6n}c_1^{6n} =$ a constant $= B$, whence the respective concentrations necessary for equal coagulative powers are $c_1 : c_2 : c_3 = 1 : x^{-1} : x^{-2}$, where $x^{-1} = B^{1/6n}$. The coagulative powers of monad, dyad, and triad metal ions are therefore in the ratios $1 : x : x^2$. If $x = 32$ this gives the series 1 : 32 : 1024 to compare with Linder & Picton's 1 : 35 : 1023 : if $x = 40$ we get 1 : 40 : 1600 to compare with Schultze's 1 : 30 : 1650. By parity of reasoning, tetravalent elements would have very large coagulative powers. A. D.

541. *Effect of Salts on the Strength of Acids.* **S. Arrhenius.** (Zeitschr. Phys. Chem. 31. pp. 197–229, Dec. 22, 1899.)—The author determines the effect produced on the rates of inversion of cane sugar by acetic, formic, or phosphoric acid by the addition to them of varying quantities of the following salts : potassium chloride, chlorate or nitrate, sodium chloride, bromide or nitrate ; the greatest concentration of the salt solution employed being 0·125 normal. The results show that the relative increase (z) of the inversion velocity is nearly proportional to the square root of the quantity (c) of salt present. Thus, if c and z are the values for one salt solution, and c' and z' for another, the numbers for 0·05 normal acetic acid and sodium chloride give $\log z/z' : \log c/c' = 0{\cdot}543$, the corresponding ratio for 0·025 normal acetic acid and potassium nitrate, chloride or chlorate or sodium nitrate, having the value 0·52. Taking into account the dissociation of the acids, it is seen that as the

concentration of hydrogen ions in the solution increases, the value (x) of the above ratio shows a continuous increase, z at the same time gradually decreasing. Whilst the sugar-content of the solution has no appreciable influence on the value of x, the temperature on the other hand produces a very marked effect.

The changes caused in the reaction velocities of weak acids by the addition of salts, as determined in this way, are complicated by three disturbing factors for which corrections are made: (1) The action of the neutral salt itself in producing sugar inversion; (2) A slight chemical action between the acid and the added salt: (3) The action of the salt in increasing the dissociation constant of the acid; corresponding to this a similar increase is obtained in the dissociation constant of a salt solution as the concentration increases, and in both cases the increase obeys the same law. Ostwald's dilution law, in all probability, does not hold exactly for any electrolyte; in the case of weak acids and bases the deviations lie within the limits of experimental error, but these deviations increase with the dissociation constant and have their greatest values for the most strongly dissociated bodies, viz., salts, and strong acids and bases.

A series of experiments made with solutions of varying strengths of the mixtures, KCl and NH_4Cl, KNO_3 and $KClO_3$, and KNO_3 and $NaNO_3$, shows that the conductivity of a mixture of two salt solutions of equivalent strengths is equal to the mean of the conductivities of the separate solutions, the ionic concentration being unchanged by the mixing. Calculations made according to Noyes' view—that the dissociation factor depends only on the concentration of the non-dissociated part of the dissolved salt—do not agree with the observed numbers. In apparent contradiction with these experiments is the diminution in the solubility of a slightly soluble salt effected by the addition of one of its ions to the solution; in this case it is assumed that the solubility of the non-dissociated portion of the dissolved salt remains constant. From the results of experiments on the sodium and silver salts of valeric, monochloracetic, butyric, propionic, and acetic acids, the author concludes that this assumption is erroneous, as the solubility of the non-dissociated silver salt decreases very considerably when the corresponding sodium salt is present. Similar behaviour is exhibited by the solubility in water of potassium hydrogen tartrate when methyl or ethyl alcohol, cane sugar or glycerine is added to the solution.

T. H. P.

542. *Heats of Fractional Neutralisation of Hydroferrocyanic and Hydroferrocarbonylcyanic Acids.* **J. A. Muller.** (Comptes Rendus, 129. pp. 962–964, Dec. 4, 1899.)—The author finds for each gramme atom of hydrogen neutralised in the acids $H_4Fe(CN)_6$ and $H_3FeCO(CN)_5$ the same value for the heat-evolution, viz., 14 Cal. The solutions were dilute, the temperature about 18·6° C., and the bases employed, potassium and Barium hydrates. The conclusion is that these acids are both *strong*, or, expressed in modern language, that they are nearly completely dissociated in dilute solution. F. G. D.

543. *Thermochemical Study of Narcein.* **É. Leroy.** (Comptes Rendus, 129. pp. 1259–1261, Dec. 26, 1899.)—The author's experiments were made with a sample containing *two* molecules of water of crystallisation. When dissolved in boiling water and recrystallised by cooling, the ordinary hydrate with *three* molecules of water of crystallisation was obtained. Determinations were made of: (1) The heat of hydration (by dissolving the anhydrous base and the two hydrates in dilute potash solution); (2) The heat of combustion,

and therefore the heat of formation from the elements; (3) Heats of formation and hydration of the hydrochloride; (4) Heat of formation of the potassium salt in dilute solution.

Reference must be made to the original paper for the figures. The author concludes that narcein is a very feeble base, in fact the weakest of the opium alkaloids. It possesses an electrolytically dissociable hydrogen atom, and so acts as an acid. In this respect, however, the heat of formation of the potassium salt, although greater than that of the phenates, is considerably less than that evolved in the formation of such salts as acetates, benzoates, &c.

F. G. D.

544. *Influence of the Solvent on the Cryoscopic Behaviour of Phenols.* **K. Auwers** (with **H. M. Smith** and **W. Bartsch**). (Zeitschr. Phys. Chem. 30. pp. 300–340, Nov. 1, 1899.)—The abnormal cryoscopic behaviour of certain phenols, which has been shown—Zeitschr. 18.595 (1895); 21.337 (1896); 23.449 (1897)—to depend in a regular way upon their constitution, cannot be satisfactorily explained by the assumption that association takes place, since the effect of dilution on the cryoscopic values does not correspond with the laws of dissociation, and moreover the association factors in solution would require to be much greater than those observed by Ramsay and Shields in the case of liquids. The extent of the deviations does not depend in any regular way upon the freezing-point of the solvent or the magnitude of its depression constant; thus in the case of p-dichlorobenzene and p-nitrotoluene, which have nearly the same melting-point (53° and 52°) and depression constant (77 and 78), the deviations in the apparent molecular weight of p-hydroxybenzaldehyde are 400 and 39 per cent. respectively; it is, however, influenced in a regular way by the constitution of the solvent. The deviations are greatest in p-dichlorobenzene, p-chlorobromobenzene, and p-dibromobenzene, and are much less marked in the nitro-derivatives of benzene and toluene; in the case of the three di-halogen-benzenes a regular gradation is observed in the apparent molecular weights of all the substituted phenols examined. For solutions of p-nitrophenol in nitrobenzene, p-chloronitrobenzene, p-nitrotoluene, and m-dinitrobenzene, the deviations in the apparent molecular weight are almost independent of the concentration; this is explained by the formation of solid solutions, owing to the similarity in structure of the solvent and solute.

T. M. L.

545. *Potential between Metals and Non-Aqueous Solutions.* **L. Kahlenberg.** (Journ. Phys. Chem. 3. pp. 379–403, 1899.)—Eighty-nine results are given for metals immersed in non-aqueous solution of salts. In the case of solutions containing the same quantity of salt per litre, the P.D. appears to depend upon the nature of the solvent: solvents of a similar chemical nature give results which are nearly the same. As a rule, the electrolytic solution pressure of the metals for these various solutions cannot be calculated for lack of data. The conductivity is usually low, giving no limiting value, and cryoscopic methods are not sufficiently sensitive. It has also been found that high conductivity may be accompanied by normal molecular weight. Many contradictory results are found, from which it appears that if the osmotic pressure theory be true the solution tension must vary with the solvent.

W. R. C.

546. *Reflecting Power of Electro-Deposited Metals.* **S. Cowper-Coles.** (Electrician, 44. p. 267, Dec. 15, 1899.)—Silver was deposited on glass and backed with copper, the deposit then separated from the glass, and the silver coated

with the respective metal. The tests were made with the help of a Bunsen photometer and pentane standard lamps. If the reflecting power of silver is 100, chromium is 100, platinum 74, palladium 64; for chemical rays and astro-photography platinum and palladium appear, however, superior to silver. Silver is, moreover, soon tarnished, in proximity to an arc lamp, whilst palladium keeps its reflecting power. Nickel is unsuitable for arc lamps. When a polished brass plate is silvered, and then thinly gilded and finished, and finally coated with a very thin film of palladium, the reflecting powers are: gold 77, palladium 63, *i.e.*, almost the full value for palladium, although the gold could distinctly be seen through it. The angles of incidence are not stated. As to the electro-deposition of palladium, see Abstract No. 1749 (1899).

H. B.

547. *Electrolytic Trees of Copper.* **S. Cowper-Coles.** (Electrician, 44. pp. 288–289, Dec. 22, 1899.)—The author describes the results of experiments made with a view to determine the effects of variation in the current density, in the strength, acidity, and temperature of the electrolyte, and in the shape of the kathode, upon the formation of the irregular deposits known as trees or nodules. A current density of 60–70 amperes per square foot was found to be most favourable to "treeing." No other definite conclusions are given. Six photographs of deposits obtained in these experiments are reproduced.

J. B. C. K.

548. *Electrolytic Deposition of Zinc under Pressure.* **S. Cowper-Coles.** (Electrician, 44. p. 183, Dec. 1, 1899.)—The experiments described by the author in this brief note were undertaken in order to find the effect of pressure upon the cohesion and other physical properties of the deposited zinc. Mild steel plates were used as kathodes, with lead or zinc as anodes. The electrolyte was a solution of zinc sulphate containing free acid and zinc dust. A pressure of one ton per square inch was maintained in the cell during electrolysis. Current densities varying between 17 and 100 amperes per square foot were used. The best results were obtained with a current density of 50 amperes, but no details of the cohesive or other physical properties of the deposit are given. Three photographs of the deposits obtained are reproduced.

J. B. C. K.

549. *Great Falls and Anaconda Copper Refineries.* (Electrician, 44. pp. 251–254, Dec. 15, 1899.)—A description of the electrical generating machinery at the Great Falls Refinery of the Boston and Montana Company, and at the Anaconda Refinery, Montana.

The first is driven by water-power, the second by steam-power. The head of water at Great Falls is 50 feet. A 2,900 H.P. twin-turbine drives two Westinghouse generators, each rated at 810 kw., but regularly driven to yield 1,210 kw. The current supplied by each of these dynamos is 5,500 amperes, at 220 volts pressure. Details of the construction and views of these large dynamos are given. The copper conductor used for conveying the current from the generating house to the depositing tanks is 12 inches wide, 2 inches thick, and half a mile in length. The anodes are pigs of raw copper, 24 inches square and 2 inches thick; they are cast with projecting bars to facilitate hanging in the vats. The 1898 Report of the Boston and Montana Company shows that the sales of copper, silver, and gold were valued at £1,500,000, and that profits equal to £700,000 were made.

The generating machinery at the Anaconda Refinery is likewise of

Westinghouse construction. The units are, however, much smaller than at Great Falls, and are as follows: Three 270-kw. dynamos, belt-driven; four 270-kw. dynamos, direct coupled; two 360-kw. dynamos, direct coupled. Some details of the commutator construction of these machines are given.

J. B. C. K.

550. *Aluminium.* **J. H. Henderson.** (Indus. and Iron, 27. p. 395, Dec. 15, 1899. Abstract of a paper read before Manchester Junior Elect. Engineers, Nov. 28, 1899.)—This Abstract gives some details concerning the electrolytic method of producing aluminium from the oxide, and a few facts relative to the use of the metal for electrical purposes, and to the precautions necessary in casting and when working it in the lathe.

The composition of the molten bath used for dissolving the dry alumina is given as: Fluoride of calcium, 234 parts; double fluoride of cryolite [? cryolite itself], 421 parts; fluoride of aluminium, 845 parts; calcium chloride, 3 to 4 per cent.

This bath is heated to 1,210° F., alumina is added, and the electrolytic decomposition is carried out with an E.M.F. of 6–8 volts and a current density of 216 amperes per square foot. One pound of the metal should be obtained per 5 E.H.P. hours. J. B. C. K.

551. *Electrolytic Production of Aluminium.* **G. H. Robertson.** (Electrician, 44. pp. 287–288, Dec. 22, 1899.)—The author in this short article gives some historical details relating to the electrolytic processes for reducing aluminium oxide, and then passes on to a description of those processes in which the sulphide is substituted for the oxide. The latest of these is the Gooch process, in which the sulphide is formed from the oxide in the electrolytic bath itself by chemical action.

In this process the solvent for the oxide is a fused mixture of sodium fluoride and aluminium chloride. The anodes are of carbon; the carbon lining of the bath acts as kathode. The anodes are perforated longitudinally, and the carbon disulphide is conducted into the bath as vapour through these perforated anodes. The bath is fed with alumina, and the sulphur, carbon monoxide, and carbon oxy-sulphide which result from the electrolytic and chemical decompositions pass away as gases. The E.M.F. required for the decomposition is said to be only 0·90 volt. J. B. C. K.

REFERENCES.

552. *Primary Batteries.* **W. R. Cooper.** (Electrician, 44. pp. 226–228, Dec. 8, 1899.)—Seat of the E.M.F. in a voltaic cell.

553. *Electrochemical Industry.* **W. Borchers.** (Eng. Mag. 18. pp. 389–402, Dec., 1899.)—This article is a presentation in more popular form of the facts and figures contained in the paper read before the 1899 meeting of the German Electrochemical Society at Leipzig. (See 1899, Abstract No. 1947.) After an introduction describing the various forms in which energy is found upon this earth, the author states that the use of the potential energy of the coal-beds is about to be exchanged for the use of the kinetic energy of moving or falling water. Very brief descriptions of the processes and apparatus used in all the chief electrochemical and electrometallurgical industries are then given, and the author concludes by pointing out that 90 per cent. of the estimated output of these new works and factories is due to the utilisation of water-power. J. B. C. K.

554. *Cost of Calcium Carbide.* (Engineer, 88. pp. 611–612, Dec. 22, 1899.)

STEAM PLANT, GAS AND OIL ENGINES.

555. *Mechanical Draught and Boiler Efficiency.* **W. B. Snow.** (West. Electn. 25. pp. 74–75, Aug. 5, 1899. Extract from lecture delivered before the Engineering Society of Columbia University.)—Estimates are given of the relative costs and fixed charges for boiler plants having chimney draught, and induced and forced draught without chimneys. An average of the costs of nine representative plants shows the total expense for installing a forced draught plant to be only 18·7 per cent.; that of a single induced fan and accessories 26·7 per cent., and that of a complete duplex induced draught plant, 42 per cent. of that of a chimney. In each case a short steel-plate stack is included. J. T. R.

556. *Internal Self-oiling Ball Engine.* (West. Electn. 25. p. 88. 1899.)—The distinctive feature of the new design of the Ball engine is the automatic oiling system. The oil is contained in a pocket in the bottom of the crank chamber, and the crank discs in revolving carry over a portion of this oil into a trough in the top of the frame, from which the oil flows to the main bearings and is carried by radial holes to the crank-pin. There are removable plates one on each side of the connecting-rod at the ends of the guides, so arranged that they guide the oil directly into the crosshead. The lower guides are so designed that the crosshead floats on the oil, and the area of the slides being large the wear is practically eliminated. The oiling is claimed to be automatic, positive, and requiring no attention. The Company supply self-oiling engines, simple, tandem, cross-compound, and either side-crank or centre-crank as desired. A. S.

557. *Feed Water Heaters for Locomotives.* **C. M. Muchnick.** (Mech. Eng. 4. pp. 637–638, Oct. 28, 1899. From the American Engineer and Railroad Journal, Oct., 1899.)—The author describes two feed water heaters for locomotives, used on the Paris-Orleans Railway and the Western Railway of France respectively. Lencauchez, engineer of the Paris-Orleans Railway, designed a heater combined with an oil separator. The exhaust steam taken from each cylinder is led into an oil separator formed of a number of hollowed-out plates, assembled in such a manner that the steam has to make several up-and-down courses, leaving the oil on the hollowed-out portions of the plates. The steam thus purified passes into the heater proper, where it comes in contact with the cold water which falls, fountain-like, over a series of trays, each having a finely divided toothed edge. The division of the cold feed water into very small streamlets facilitates the rapid mixture of the cold water and steam. A pump then forces the feed water into the boiler at a temperature of 192–203° F. The feed heater is provided with check valve, safety valve, and gauge glass.

In the feed water heater designed by Chapsal, engineer of the Western Railway of France, the cold feed water passes over a series of cones in which steam circulates. Thin deposits from the impure feed water are formed on the surface of the cone, and when broken by the contraction of the latter accumulate around the bottom edges of the cones. It was found that the deposits of laminated tartar when weighed in a dry state varied from 22 lbs. to 44 lbs. for a running distance of 1,875–3,750 miles. A. S.

558. *Hydraulic Boiler Test.* (Mech. Eng. 4. p. 623, Oct. 28, 1899. From Proc. of the American Boiler Manufacturers' Association, "Power.")—The boiler was a cylindrical multitubular shell boiler, made of steel plates ¾ inch thick, the steel having a tensile strength of 55,000 lbs. Size of boiler, 5 feet diameter and 14 feet long. Tubes of steel, 50 in number, and 3½ inches diameter. The shell was divided into three rings, A, B and C, the circumference of each containing two plates. The vertical or circumferential ring seams were single-riveted lap-joints; the transverse or horizontal seams were as follows: In ring A, on one side of the boiler a triple-riveted lap-joint with inside covering strap, and on the other side a quadruple-riveted butt-joint with outside and inside straps. In ring B, a triple-riveted lap-joint, same as in A, and a triple-riveted butt-joint with inside and outside straps. In ring C, a triple-riveted butt-joint, and a quadruple-riveted butt-joint, both having inside and outside straps.

Under a pressure of 450 lbs. per square inch, the shell became ⅛ inch shorter than normal size, whilst the circumference at the centre of the rings measured as follows: At A, ⅛ inch longer; at B, ⅜ inch longer; at C, ¼ inch longer, the boiler remaining tight. At 650 lbs. pressure the boiler became ⅜ inch shorter, at ring A the circumference increased to 2¼ inches above normal size, at B 3⅜ inches, and at C 2¼ inches. The boiler then leaked at the rivets. At 725 lbs. pressure, the vertical seam between rings A and B, and the butt-joint in ring B showed cracks. F. J. R.

559. *Tests of Machinery on Board Ship.* (Mech. Eng. 4. pp. 626–629, Oct. 28, 1899. From **B. C. Bryan** and **W. W. White,** of U.S. Navy, in Jour. American Soc. of Naval Architects.)—These tests give economic results obtained from the water-tube boilers and the main and auxiliary engines of the American lake steamer *Pennsylvania,* the boilers having been fired by a mechanical underfed stoker, using an inferior quality of slack coal, with forced draught from a Sturtevant blowing-fan which delivered the air through tuyere blocks—no air entering the fire from the ashpit. A test sample of the coal yielded calorific power equal to 11,790 British thermal units per pound when dry. The quantity of steam used by each of the auxiliary engines, and also the amount required to work the stokers, were, in addition, separately ascertained.

The boilers were of the Babcock and Wilcox marine type, with generating tubes 2 inches in diameter, No. 10 B.W.G. in thickness; each boiler occupying a space of 9 ft. 3 in. long, 12 ft. 6 in. wide, and 16 ft. 8 in. high, and having 3,000 square feet of heating surface. They weighed, without water, 145,860 lbs. (about 65 tons), and with water, 179,352 lbs. The working steam pressure was 250 lbs. per square inch. The weight of each stoker complete was about 3,500 lbs. The coal was fed continuously from a hopper by a screw conveyer into the central magazine of the stoker, in which it was gradually pushed upwards until it covered the tuyeres or air-blocks through which the fan blast was directed, both towards the central magazine and towards the outside of the fire. Each stoker had a side door through which the fuel on the dead grate was sliced at about twenty-minute intervals, and thoroughly clinkered and cleaned every six hours. These doors also permitted stoking by hand when desired, or in case of any break-down of the mechanical-feeding arrangement, but their opening afforded the only occasions on which smoke was produced. The following is a summary of the tests made—those marked No. 6 (*a, b,* and *c*) having been of short duration, to show the effect of reduced boiler pressure:—

SUMMARY OF TESTS OF MACHINERY ON STEAMER "PENNSYLVANIA."

Number of test	1	2	3	4	5	6a	6b	6c
Date (1899)	May 28[1]	May 30	May 30–31[2]	May 31[3]	June 1[4]	June 1		
Duration of test, hours	6	6	6	6	6	3	2	1
Average boiler pressure, gauge	242·0	244·2	240·8	245·3	245·0	197·4	129·8	108·3
Main engines : Steam pressure at engines	239·4	238·1	237·2	241·8	241·8	193·4	125·8	104·3
Vacuum, inches	24·35	23·56	22·73	22·71	23·67	23·40	21·60	21·16
Cut-off in high-pressure cylinder	·644	·658	·798	·542	·656	·656	·656	·656
M.E.P. reduced to low-pressure cylinder	31·48	31·70	36·93	26·24	32·01	25·71	15·59	11·87
Revolutions	77·33	74·45	79·44	66·31	73·74	67·10	51·02	44·93
Indicated H.P.	1,206·71	1,169·77	1,455·04	862·78	1,168·88	855·87	394·94	264·89
Feed water : Average temp. leaving heater	222	213·2	219	226·5	181·5	200·1	217	218
Total lbs. : Fed to boilers	122,439	116,136	146,089	89,566	98,026	45,937	18,390	7,615
Used by main engines	103,509	100,167	125,711	76,351	...	38,818	13,630	5,303
Used by auxiliaries and stokers	18,930	15,969	20,378	13,215	...	7,119	4,760	2,312
Lbs. per hour—main engines—total	17,252	16,694	20,952	12,725	...	12,939	6,815	5,303
Main engines—per I.H.P.	14·30	14·27	14·40	14·75	...	15·12	17·26	20·02
Auxiliaries—total	3,155·0	2,661·5	3,396·3	2,202·5	...	2,373·0	2,380·0	2,312·0
Per I.H.P. developed by main engines	2·61	2·28	2·33	2·55	...	2·77	6·02	8·73
Total per I.H.P. developed by main engines	16·91	16·55	16·73	17·30	16·77	17·89	23·28	28·75
Exhaust steam actually sent to feed heater[5]	14·78	13·02	13·08	13·83	...	10·59	17·41	18·79
Total steam used by auxiliaries, per cent.	15·46	13·75	13·95	14·75	...	15·50	25·88	30·36
Coal : Total, lbs.	14·400	14,200	18,000	11,800	14,750	...	...	...
Per cent. of moisture	3·3	3·3	3·3	3·3	3·3	...	...	...
Total, dry, lbs.	13,925	13,731	17,406	11,411	14,263	...	...	...
Total, dry, per hour, lbs.	2,321	2,289	2,901	1,902	2,377	...	...	...
Total dry, per I.H.P. hour for main engines	1·63	1·69	1·72	1·88	...	...	...	...
Total, dry, per hour for all machinery in use	1·92	1·96	1·99	2·20	2·03	...	...	...
Refuse : Total	2,183	2,575	3,800	2,463	...	...	...	...
Per cent. in dry coal	15·68	18·75	21·83	21·58	...	...	...	...
Water evaporated, per lb. : Dry coal—Actual conditions	8·79	8·46	8·39	7·85	8·25	...	...	...
Water evaporated, per lb. : Dry coal—From and at 212°	9·24	8·97	8·85	8·21	9·02	...	...	...
Water evaporated, per lb. : Combustible—Actual conditions	10·43	10·41	10·74	10·01	...	...	...	...
Water evaporated, per lb. : Combustible—From and at 212°	10·96	11·03	11·32	10·74	...	...	...	...

[1] Preliminary tests ; weight of coal used unreliable. [2] Auxiliary water exhausted to atmosphere by blower equal 432·8 lbs. [3] Leak around gland of feed pump during test equal 396 lbs. [4] Total feed water weighed only during five hours of test. [5] Given in per cent. of total steam used for all purposes.

The main engines were of the usual vertical, inverted, direct-acting type, arranged for quadruple expansion, with a jet condenser—the maximum H.P. being 1,600. The original paper gives details of sizes and make of the various parts of the machinery.

The average quantity of steam consumed per hour by the various auxiliary engines, which were mostly compound engines (excluding the stoker motors), is shown by the following table of results of tests made on May 28 :—

Auxiliary.	Steam Consumption per Hour.			
	Table I.	Table II.	Table III.	Table IV.
	Lbs.	Lbs.	Lbs.	Lbs.
Air pump	721	715	828	613
Feed pump	487	468	595	350
Bilge pump	275	275	320	240
Water-service pump	146	154	156	150
Auxiliary pump	330	...	...	...
Starboard dynamo	...	480	480	...
Port dynamo	671	...	...	...
Steering engine	125	125	125	125
Fire-room blower	622	692	725	550
Total	3,377	2,909	3,229	2,028

In addition to these, the stoker motors showed an average consumption of 23·1 lbs. of steam per hr. per motor, the total quantity for all the stokers amounting to 138·6 lbs. per hr. The cost of operating all stokers and blower, based on these results, was 4·29 per cent. of the total steam generated. Allowing for the blower exhaust steam having been passed through the feed heater, the net cost of the stoker installation is taken as equivalent only to 1·68 per cent. of the total steam.

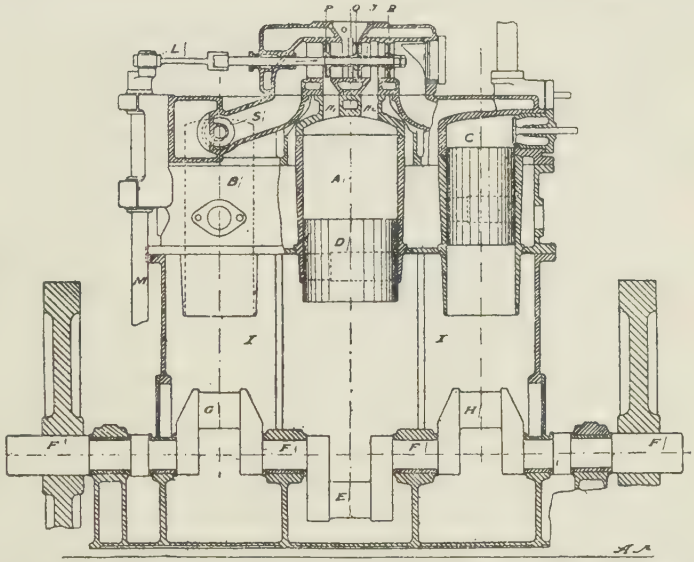
The exhaust steam from the auxiliaries was employed in a feed heater, but when the temperature of the feed water was increased to about 225° F., or higher, the back pressure from the heater shell caused irregular working of the pumps. The upper limit of feed heating appeared to be about 200° F., or an average of approximately 95° F. increase in temperature of the water taken from the hot well, the auxiliaries then consuming about 10·5 per cent. of the total steam generated. F. J. R.

560. *Flow of Water through a Surface Condenser.* **M. Longridge.** (Mech. Eng. 4. pp. 602–603, Oct. 21, 1899. From the Annual Report of the chief engineer of the Engine, Boiler, and Employers' Liability Insurance Company.) —Little is known about the pressure required to force the circulating water through a condenser. The author made an experiment on a condenser containing 679 tubes, ¾-inch external diameter, and 6 ft. 2 in. long. The circulating water was supplied by a centrifugal pump through a 6-inch pipe connected to the bottom branch of the waterhead of the condenser ; it traversed the length of the condenser twice, and flowed away from the upper part of the condenser through a 6-inch pipe.

In one experiment the quantity of circulating water was 1·72 cubic feet per second, and the difference of pressures in the inlet and discharge pipes, allowing for the difference in level, was 3·05 feet head of water. The discharge pipe was not full of water, and therefore the figure given does not

represent the head lost in the condenser. Assuming the discharge pipe to have been half full, the author calculates that the resistance of the condenser was equivalent to a head of 4·25 feet. In another experiment, in which the quantity of circulating water was 1·21 cubic feet per second, the resistance of the condenser was 2·45 feet. The resistance therefore varied approximately as the square of the velocity. The greater part of the loss probably occurred at the entrance and exit from the tubes, and in passing through the narrow opening in the distance piece of the waterhead. If the length of the tubes had been doubled, the total resistance of the condenser would not have been materially increased. A. S.

561. *Improvements in Gas Engines.* (Automotor Journal, 4. pp. 160–161, Jan., 1900.)—Messrs. Crossley and Atkinson, of Manchester, have adopted the "compound" or two-stage expansion principle in internal combustion motors. The vertical engine (see fig. of sectional elevation) has two high-pressure cylinders, B and C, into which the charges of gas and air are drawn, compressed,



ignited, and expanded, and exhausted on the ordinary Otto cycle. The explosion or working strokes are made alternately, giving an impulse every revolution. After the working stroke in either high-pressure cylinder the exhaust takes place into the low-pressure cylinder A through the exhaust valve passages and the ports in the piston valve J, and N_1 or N_2, whilst the port, O, leads to the atmosphere. The pistons of the H.P. cylinders are connected to crank-pins, G and H, and make their inward and outward strokes together, but 180° from the crank-pin E of the low-pressure piston D. In the Fig., the left-hand high-pressure piston has completed its upward exhaust stroke, the exhaust valve, S, being open, and the gases passing through N_1 have already done their work on B during its down stroke, whilst the compression stroke in C is completed. Next we have the upward exhaust stroke in A, and the downward suction in B, and explosion in C. Then follows the exhaust from C, doing work in A, during compression of charge in B, and so on.

In this way power is given out by the low-pressure piston once every revolution, and between the working strokes in the high-pressure cylinders.

The low-pressure cylinder is twice the area of the high-pressure cylinders and their ends are open to an enclosed crank-chamber I, the L.P. piston and rod are about the weight of the two H.P. pistons and their connecting-rods, so that by balancing the rotating parts, the engine is suitable for running at a high speed without causing serious vibration. The cycle of operations is completed during one to-and-fro movement of the piston-valve whilst the crank-shaft makes two complete revolutions, with an impulse from each of the H.P. cylinders, and two working strokes of the low-pressure cylinder.

W. R.

562. *Griffin's Oil Launch-Engine.* (Engineering, 68. pp. 670–671, Nov. 24, 1899.)—The novel feature of Griffin's oil engine, like his gas engine, is the vertical marine form, and the use of two cylinders with a single cross-head and connecting-rod, giving an impulse every revolution. The engine is non-reversible ; hence to go ahead or astern two independent propeller screws are provided, one right-handed and the other left, one being mounted on a hollow shaft of Delta metal outside the solid steel shaft carrying the other screw, and both controlled by a lever. To start the engine the fly-wheel, which is connected to its shaft by a clutch, is released and the wheel put in rapid rotation by a hand wheel and chain, storing energy sufficient to carry the engine through two or three revolutions when the clutch is thrown into gear. The vaporiser is heated by the exhaust gases passing around it. To vaporise the oil it is first sprayed or atomised by an air blast at a constant pressure of 10 lbs. per square inch, and then heated in the vaporiser by hot air and radiation to avoid distillation of the oil. The combustible charge is diluted with the products of combustion until the best rate of combustion is obtained so that the engine runs smoothly, without the shock or knock produced by sudden explosion. The governor controls a small air valve. When the air is cut off no spray is formed, and there is no explosion in the cylinders. The illustrations show views of the engine and two propellers, with sections of these and the cylinders and vaporiser. The indicator diagram gives the mean pressure as 70 lbs. per square inch. The engine is fitted in a launch, which attained a speed of seven miles an hour on the Thames at Kingston.

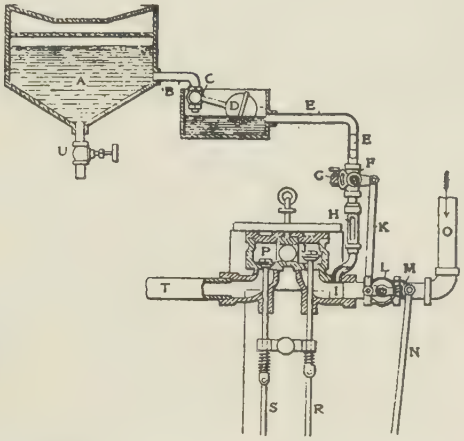
W. R.

563. *Stanley Steam-Car.* (Indus. and Iron, 27. pp. 397–398, Dec. 15, 1899.)—This describes a two-seated steam-car, the main features of which are the small vertical cylindrical steam boiler, placed under the seat, provided with 300 small vertical fire-tubes, 0·44 inch diameter, opposite to the bottom ends of which are 114 Bunsen burners, burning carburetted air produced by the evaporation of gasolene. Between the bottom tube-plate and the bottom of the boiler is a pair of plates into which are fitted a large number of short air-tubes, around the upper ends of which are drilled in the plate a number of small holes—through these holes issues the warm carburetted air inducing a current of air through the short tubes constituting a Bunsen burner. The gasolene or petroleum spirit is evaporated under slight pressure by being passed through a tube above the top tube-plate, and escapes through a small jet in a bell-mouthed opening into the space between the two plates at the bottom of the fire-box. The quantity of the vapour escaping at the jet is automatically regulated by a diaphragm which is controlled by steam pressure. The boiler is strengthened by a double winding of steel piano wire, 0·9 mm. diameter.

Motion is given to the car by a pair of vertical cylinders, 2½-inch bore and 3½-inch stroke, fitted with link reversing motion, and driving the rear axle by a chain : this runs on a sprocket wheel on the crank shaft and on the exterior of the differential gear on the axle. Fifteen gallons of water are carried, nominally sufficient for a 25-mile run. W. W. B.

564. *Secor's Kerosene Motor.* (Mech. Eng. 4. pp. 596–597, Oct. 21, 1899. From "American Machinist.")—The fuel used in this internal combustion engine is kerosene oil, having a heating value of 20,700 British thermal units per pound, costing about one cent. The charge contains a certain proportion of oil and air for perfect combustion. The speed is regulated by the governor, which controls the admission of both fuel and air, and thereby increases or decreases the volume of this perfectly combustible mixture.

The Secor motor is of the high-speed vertical marine form. The oil feed is by gravity, without any "carburetor" or pump. The oil falls from the supply tank A (in the fig.), into the constant-level tank V to obtain constant



head for the flow through the bent pipe E to the fuel admission valve F. The air admission is by O and the butterfly valve at L. The governor-rod N actuates both the valves L and F by the rod K. By an independent micrometer adjustment at G and M, the oil and air can be delivered to form a perfectly combustible mixture, whilst the regulation of the speed is effected by throttling the volume of the charge and so reducing the compression. The admission valve J is operated by the rod R, and the exhaust valve P by rod S, from cams of the usual type, timed on the Otto cycle. Ignition is by electric spark from a Rhumkorff coil, excited by current from six cells. It is stated that small sizes of this motor give power at a fuel cost of ½ cent per H.P. hour. W. R.

565. *Gobron and Brillié Autocar.* (Indus. and Iron, 27. pp. 429–430, Dec. 29, 1899.)—This describes the motor and gear employed by the Société Gobron and Brillié for their petrol motor vehicles. The motor has four pistons working in opposite directions in two vertical cylinders, the pistons being coupled to a three-crank shaft, the two lower pistons acting on one crank while the two upper pistons act on a crank fixed at 180° to that for the lower pistons. The explosions take place between the pistons in each

cylinder so that the motor is balanced both for impulse and weight of moving parts. The petrol is vaporised in the supply pipe leading to the admission valves, the quantity of petrol required per double stroke being fed by means of a rotating toothed cone disc, which is operated from the crank shaft of the motor in such a manner that one toothful of petrol is delivered per revolution to the vaporising chamber, except in the case of the speed of the motor exceeding the normal when the governor comes into action and cuts off the supply. The air admission to the vaporiser is arranged so that part of the air is sucked through a passage opening into the tooth which is full of petrol, and thus the petrol is swept with the air into the vaporiser. The motor drives by means of a spur gear through a friction clutch on to a countershaft; this in turn drives the countershaft, carrying the sprocket pinions of the chain drive by means of one of three sets of spur wheels and pinions, which give three speeds to the vehicle. This countershaft carries the differential gear, and, at its ends, the sprocket pinions which drive through pitch chains on to sprocket-wheel rings carried from the spokes of the rear road wheels. The steering of the vehicle is on the Ackerman system, and is controlled by a hand wheel which operates the pivots of the steering wheels through a form of epicycloidal gear; this gives a "variable multiplication of the ratio of movement between the hand wheel and the front road wheels." Three band brakes are fitted, one on the chain pinion countershaft and one on each of the driving road wheels. W. W. B.

566. *Darracq Autocar.* (Automotor Journal, 4. pp. 106–108, Dec., 1899. Adapted from an article by **L. Baudry de Saunier** in La Locomotion Automobile.)—This is a light four-wheel carriage, to seat two or four persons, driven by petrol motor, having a single horizontal air-cooled cylinder, designed by Bollée, and capable of giving 5 H.P. at 800 revolutions per minute. The motor is carried at the front end of the tubular under-frame, and is placed with the combustion chamber in front so as to get the full benefit of the cooling effect of the stream of air when the vehicle is in motion. On an extension of the crank shaft to one side of the crank case is mounted a four-speed belt cone from which the power is transmitted by a single belt to a corresponding four-speed cone on a countershaft carried at the back of the under-frame. This belt cone drives, through a friction clutch, a spur pinion gearing with a spur wheel on the exterior of the differential gear, which is mounted on the driving axle of the vehicle. Reverse motion is imparted to the carriage by means of internal spur gear, which, when brought into action, reverses the direction of rotation of the speed cone on the crank shaft of the motor. The carriage body is connected to the under-frame in such a manner as to be readily detachable. The body and frame are supported from the axles by leaf springs, and are further insulated from shocks due to rough road surfaces by means of pneumatic tyres on the wheels, which are of the cycle type. Steering is effected by the front wheels on the Ackerman system. Three band brakes are available for checking the motion of the vehicle in either direction. W. W. B.

567. *Bennett and Thomas Petrol Motor.* (Automotor Journal, 4. pp. 99–102, Dec., 1899.)—This is an engine worked with carburetted air, provided with two cylinders on opposite sides of a two-crank shaft, the centre lines of the cylinders being separated by a very short distance. The pistons and connecting-rods are similar to ordinary practice, but the pistons have very little clearance, the necessary compression and combustion space consisting of one

long passage connecting the outer ends of the two cylinders. In branches from this passage are the seats of the two piston valves, one admission and one exhaust, worked by a simple arrangement of cam-actuated levers of the second order. Electric ignition is employed, and the governor acts on an ordinary butterfly valve. W. W. B.

568. *Ignition or Sparking Tube.* (Automotor Journal, 4. p. 99, Dec., 1899. **L. Baudry de Saunier,** in La France Automobile.)—The main point in this ignition or sparking plug is the form of housing given to the porcelain plug and insulation which permits the use of a two-part porcelain, through which one conducting wire passes. Object, to keep down temperature of outer projecting porcelain and reduce breakage. W. W. B.

569. *Buchet Variable Speed-Gear.* (Indus. and Iron, 27. p. 413, Dec. 22, 1899.)—The pulleys of this belt speed-gear are, as in well-known devices, made in segments fitted upon pairs of radiating guide-pieces, one of which is normal to the axis, and the other set at about 45°, the whole of these latter guides forming an interrupted cone. When this cone of guides is moved to or from the normal radiating guides, the pulley segments slide radially in or out respectively, just as a door-latch slides in its guide when pushed against the hasp. The pulley segments, when close together, form a pulley about one-half the diameter of the corresponding pulley when all its segments are separated with the maximum space between each. W. W. B.

REFERENCES.

570. *Modern Steam Engine Tests,* 1888–1899. (Engineer, 88. p. 377, Oct. 13, 1899.) Three tables of twenty-nine tests.

571. *Heat Engines and Steam Turbines.* **C. A. Parsons.** (Electrician, 44. pp. 83–84, Nov. 10, 1899.)—Presidential address to the Institution of Junior Engineers.

572. *Evolution of the Stationary Steam Engine.* **A. R. Robertson.** (Instit. Civ. Engin., Proc. 138. pp. 353–363, Oct., 1899.)—Historical.

573. *Shaft Governor.* (Engineering, 68. p. 707, Dec. 1, 1899.)

574. *Steam Engine Governors.* **R. H. Smith.** (Feilden, 1. pp. 287–306, Oct., 1899.)

575. *Recent Practice in Steam Boilers in Great Britain.* **W. D. Wansbrough.** (Cassier, 17. pp. 33–47, Nov., 1899.)—A description of various types of boilers and their respective advantages and disadvantages. J. T. R.

576. *Compound Direct-Acting Boiler Feed Pump.* (Engineering, 68. p. 690, Dec. 1, 1899.)

577. *Steering-Gears with Two Pivots.* (Automotor Journal, 4. pp. 58–61, Nov., 1899; also Le Génie Civil and Engineering.)—A theoretical study.

578. *Utilisation of Blast Furnace Gases in the Generation of Electricity.* (Elect. Rev. 45. pp. 985–987, Dec. 15, and 991–992, Dec. 22, 1899.) See also Abstracts Nos. 991, 992, 993 (1898), No. 1258 (1899), and No. 297 (1900).

GENERAL ELECTRICAL ENGINEERING.

579. *Vulcain Prepayment Energy Meter.* (Ind. Élect. 8. pp. 487–490, Nov. 10, 1899.)—After describing the ordinary Vulcain meter (see 1899, Abstract No. 1419), an illustrated description is given of the supplementary prepayment attachment. This mechanism makes use of differential gear, and is so arranged that upon introducing a suitable coin and turning a key a switch is closed and a spring is wound up. The spring tends to restore the mechanism to its original position, but is controlled by an anchor escapement gearing with the meter proper. When a given quantity of energy has been used by the consumer, the switch is released, opening the circuit. The details cannot be explained without figures. Means are provided for changing the price of energy, and for checking the number of coins introduced.

A. H. A.

580. *O'Keenan Electricity Meter.* **E. O'Keenan.** (Ind. Élect. 8. pp. 505–510, Nov. 25, 1899.)—The aim of the inventor was to construct a motor which should have as nearly as possible an electrical efficiency of unity, when the counter and applied electromotive forces would be equal, and the speed of rotation proportional to the potential difference between the terminals. To this end a strong permanent magnet is used, with an iron cylinder fixed between the poles as in a d'Arsonval galvanometer ; in the narrow air-gap rotates an armature consisting solely of a shell of flat coils, cemented together, and connected with a small commutator. The iron core is supported by a bracket entering the open end of the armature ; the latter is carried by a spindle resting on a jewelled centre and guided at the upper end, and drives the recording train by means of a fine worm. No retarding device is employed, and friction is reduced to a minimum.

The instrument has various applications : (1) Connected with a battery of constant E.M.F., the dials record *time*, and may be graduated in hours, minutes, &c., thus constituting a clock, which, as the current is excessively small, may theoretically run for years without attention ; or it may be used for telephonic service, to record the time the telephone is in use. (2) For distribution at constant current, the instrument is connected through a high resistance with the consumer's terminals, and records volt-hours, and indirectly watt-hours. (3) For distribution at constant pressure, the instrument is joined in shunt to a very low resistance in series with the consumer's circuit, recording ampere-hours, and indirectly watt-hours. If it is necessary to compensate for friction, small though it be, an independent source of E.M.F. may be utilised to supply the friction torque. (4) By joining the middle wire to the middle of the low resistance mentioned in the preceding case, the instrument is adapted for recording the ampere-hours supplied to a three-wire circuit. (5) An analogous arrangement for a special case of five-wire supply is described. (6) For charging and discharging accumulators, an arrangement similar to that of (4) is explained, the instrument acting as a reversible ampere-hour meter, and making allowance for the inefficiency of the battery.

The instrument is independent of variations of temperature and of the resistance in circuit with it except at extremely low speeds, and cannot be started by external vibration, nor do external magnetic fields affect its indica-

tions, all of which faults are commonly present in other meters. The practical form of the instrument is illustrated, and it is stated that for a meter of 5 amperes capacity the shunt resistance is 0·1 ohm, the armature 12 ohms, and the meter starts with from 0·5 to 1 per cent. of the maximum load, or about 0·03 ampere in the main circuit; the armature current is then 0·0002 ampere, the potential difference 0·003 volt, and the power $0{\cdot}6 \times 10^{-6}$ watts. The armature current is almost constant at all loads. The economy of this type of meter is urged in favour of its use on constant-pressure circuits, instead of watt-hour meters with shunt coils, which are constantly absorbing energy. A. H. A.

581. *Insulation of Air Space Cables and Temperature.* **Deflacellière.** (Écl. Électr. 20. pp. 267–272, 1899, and Annales Télégraphiques, 25. pp. 95–117, 1899.)—A two-wire cable having 1 mm. coppers insulated with two 0·09 mm. papers, and covered over all with two more paper strips, was covered by a lead tube 5 mm. internal diameter without previous drying. At 16°, 24°, 40°, 60°, and 80°, the insulation was 80, 40, 17, and 2 megohms respectively. M. O'G.

582. *Speeds and Standard Periodicities.* **E. K. Scott.** (Elect. Rev. 45. pp. 996–997, Dec. 22, 1899.)—In March last the Uniformity Committee of the Institution of Electrical Engineers published its report on the adoption of a standard of periodicity in alternating current working. The Committee recommended 50 periods per second for all ordinary work, 25 periods for power transmission on a large scale, and 100 periods per second for exceptional cases of house-to-house transformer supply.

The author points out that the speeds of steam or gas engines as constructed at present are for the most part not adapted to these frequencies. W. G. R.

583. *Effect of Governors on Parallel Running of Alternators.* **L. Wilson.** (Instit. Elect. Engin., Journ. 28. pp. 389–398, 1899. Paper read before the Students' Section.)—The author explains the interactions occurring between the armatures of two alternators, which are coupled together in parallel, when not in phase. The "swinging" action which takes place between the two is studied theoretically, and also its effect on the governors of the engines; the conclusion being arrived at that quick-acting, sensitive governors are to be avoided. E. D. P.

REFERENCES.

584. *The Suppression of Arcs in Switches, Fuses, &c.* **E. K. Scott.** (Electrician, 44. pp. 218–221, Dec. 8; pp. 256–257, Dec. 15; and pp. 290–292, Dec. 22, 1899. Paper read before the Northern Society of Electrical Engineers.)—A fully illustrated paper describing in detail the most well-known switches and fuses, high and low tension, and the principles employed in their design. E. D. P.

585. *Chapman Voltage Regulator.* (Amer. Electn. 11. pp. 488–489, Oct., 1899.)—Illustrated description of an apparatus for automatically regulating the supply pressure of main generators. (See 1898, Abstract No. 987.) E. D. P.

586. *Street Box for Electric Supply.* (Ind. Élect. 8 pp. 388–392, Sept. 10, 1899.)—Descriptions of various street boxes for the ready supply of electricity to automobiles, &c. A drawing of a prepayment meter is given. E. K. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

587. *Involutes for Armature Connections.* **P. Girault.** (Ind. Élect. 8. pp. 510–512, Nov. 25, 1899.)—The author points out that the normal distance between successive involutes of a circle is always constant, and if the end connections of an armature are given this shape, the space for insulation between them will be of constant thickness. Treating the matter analytically, the author deduces formulæ and draws up a table and curves to facilitate calculations for different radii and angles spanned, but notes that as the data are generally fixed by other considerations, the involutes obtained can be used only as guides to the tracing of a suitable curve. A. H. A.

588. *Hysteresis in Armature Cores.* **E. K. Scott.** (Electrician, 44. pp. 214–215, Dec. 8, 1899.)—The author points out that the formula of C. P. Steinmetz for the hysteresis loss in the cores of alternate-current transformers cannot be applied to armature cores, and gives a numerical example showing that there is no relation between the values calculated from this formula and those ascertained by experiment.

Referring to the experiments of F. G. Baily and J. A. Ewing on the subject of rotating fields, the author discusses their bearing on the design of armature cores, and considers that in direct-current armatures working at a high induction density the hysteresis loss may have a low value, but in alternators the Steinmetz formula may be approximately correct.

The possible effects of vibration are also briefly dealt with. A. H. A.

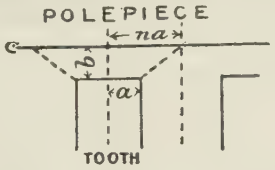
589. *Magnetic Flux in Armature Cores.* **W. E. Goldsborough.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 481–500. Discussion, pp. 501–503, Oct., 1899.)—The author determines the flux density at different points in the core by dividing that portion of a lamina that lies between the centre lines of two adjacent poles into paths of equal magnetic reluctance connecting equipotential surfaces. These paths are determined by first equalising their reluctance on the basis of a permeability of the iron of unity, and then correcting for the variations in the permeability with the varying densities by successive trial. He takes a six-pole 110 kw. railway generator and shows that the density near the inner surface of the core at no load is a little less than 3,000 gausses, while just below the teeth it is a little over 21,000 gausses. Assuming uniform distribution, the density would be 7,220 gausses, and the core loss from hysteresis 492 watts, but with the uneven distribution shown it is 663 watts, or 35 per cent. greater. At full load the distribution is still more uneven, and the core loss 830 watts. These figures refer to the solid part of the core below the teeth only. The loss in the teeth is 132 watts at no load, and 246 at full load, and 27 per cent. must be added for eddy-current losses. The total loss is 1,000 watts at no load, and 1,370 at full load. A special apparatus was made for testing the flux distributions. It consisted of an electromagnet resembling one pair of poles of a multipolar dynamo, and a section of the armature. A number of holes were bored in the armature, perpendicular to the side faces, and exploring coils wound in each pair of holes. Curves are given showing the flux distribution found by the exploring coils.

Discussion.—**Steinmetz** remarked that machines with armature iron extending down to the shaft and poles covering 80 per cent. of the pole arc will

show unequal distribution more than shallow armature cores with long distance between the poles. Experience has shown, however, that no effect of this kind appears of a magnitude to make itself felt without special investigation, so that it appears that with the relative dimensions used in most machines the effect is small, though undoubtedly existing. Where the flux is uniform at no load, change of load will not alter the distribution noticeably; it depends, however, on the relative proportion of armature reaction to field excitation.

R. B. R.

590. *Calculations Regarding Toothed-Core Armatures.* **F. Niethammer.** (Elektrotechn. Ztschr. 20. pp. 766–771, Nov. 2, 1899.)—In calculating the ampere-turns required for the air-gap the author assumes that the distribution of the magnetic lines is as shown in the accompanying sketch, the tufts of lines which proceed from the teeth spreading out fan-like until they reach the polar surface. If K stand for the number of lines proceeding from each tooth, the ampere-turns required for the air-gap are given by $K \Big/ \left\{ 1{\cdot}257 l (n+1) \tan^{-1}\left(\frac{(n-1)a}{b}\right) \right\}$, where l is the length of the pole piece measured parallel to the spindle, and the meanings of a, b and n are given by the sketch. The lines as they enter the pole-piece are not uniformly distributed, being more crowded over the areas which are immediately opposite the teeth. At a certain distance from the polar surface the distribution of the lines in the pole-piece becomes practically uniform. As the armature rotates, the local pulsations in the magnetic induction in the region of the pole-piece just considered give rise to hysteresis and eddy-current losses. The author deduces elaborate formulæ for these losses, as well as



a formula for the ampere-turns required to compensate for the demagnetising effect of the eddy-currents in the pole-pieces. The calculation of the ampere-turns required for the iron part of the magnetic circuit is next considered, and the author points out that where high inductions are used, the method commonly employed of taking the mean length of path and mean value of induction does not lead to satisfactory results, on account of the great variations in the permeability over the cross-section of the iron. He develops a method which is free from this objection, the varying length of path and varying permeability being taken into account. Considering next the case of alternate-current motors, the author emphasises the advantage of partially closing the slots, the induction being thereby rendered more uniform, with consequent reduction of hysteresis and eddy-currents; closing the slots entirely would greatly increase magnetic leakage. Formulæ are next developed for the leakage coefficients of stator and rotor, on the assumption of a standard form of half-closed slot; these formulæ, however, are much too complicated to be reproduced here.

A. H.

591. *Short-Circuit Current of Alternators.* **A. Rothert.** (Elektrotechn. Ztschr. 20. pp. 619–622, Aug. 31, 637–638, Sept. 7, and pp. 657–659, Sept. 14,

1899.)—The author shows how, from the curve connecting the E.M.F. on open circuit with the exciting current (curve α) and that connecting the short-circuit current of the alternator with the exciting current (curve β), it becomes possible to predetermine graphically the exciting current corresponding to any load of known power-factor. Let this load take a current I at a terminal P.D. of V volts, and let the current lag behind P.D. by an angle ϕ. The first step consists in finding the E.M.F. E_1 which is required (a) to provide the terminal P.D. and (b) to maintain the current I against the resistance of the armature (these two components being added vectorially). Using curve (α), we find the exciting current I_α which is required to produce E_1 volts on open circuit. Next, from curve (β) we find the exciting current I_β required to maintain a current I through the short-circuited armature. From I_α and I_β the required total exciting current is obtained by the following construction : Let I_α and I_β be taken to represent two sides of a triangle, and let the angle between them be made equal to $90° + \phi$. Then the closing side of the triangle gives the exciting current corresponding to the given load. If the curve (β) is not available, I_β may be roughly estimated, for a three-phase machine, by making use of the formula—

$$I_\beta = \frac{C}{2S} I \sqrt{2} . 1{\cdot}5 = 2{\cdot}12 \frac{C}{2S} I,$$

where C is the number of conductors per phase, I the current per phase, and S the number of turns in the field-winding. If we denote the value of I_β obtained by means of this formula by I'_β, and use I_β for the true value as furnished by the curve (β), then the ratio I'_β / I_β is, according to the author, found to vary between 0·65 and 1. The formula given above is based on the assumption that the field and armature ampere-turns are equal when the machine is run on short circuit, and that the currents follow the simple sine law. For a single-phase alternator,

$$I'_\beta = \frac{C}{2S} I \sqrt{2} . \frac{2}{\pi} = 0{\cdot}9 \frac{C}{2S} I,$$

the arithmetic mean of the armature current being used in this case instead of the maximum value. The author describes a number of interesting experiments on five machines of different types, and shows that the graphical construction described above gives results agreeing closely with experimental data. A. H.

REFERENCES.

592. *Double Voltage and Current Generators.* **A. D. Adams.** (Elect. World and Engineer, 34. pp. 742–743, Nov. 11, 1899.)—Article pointing out the advantages of combined systems, alternating and direct current.

593. *Bristol Electric Transformer Company's Factory.* (Lightning, 16. pp. 396–397, and p. 402, Nov. 2, 1899.)

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

594. *Drop in Alternating-Current Wires.* **C. P. Poole.** (Elect. World and Engineer, 34. pp. 780–781, Nov. 18, 1899.)—For the purpose of computing the difference between the bus bar E.M.F. and that at the load with any degree of convenience, the simplest method is to add together all the energy components of each element of the complete circuit; similarly add together all the inductive components, and then find the vector sum of these two arithmetical sums.

An example is given. W. G. R.

595. *Line Losses in Polyphase Transmission.* **G. T. Hanchett.** (Amer. Electn. 11. pp. 517–519, Nov. 1899.)—The author calculates the relative volumes of copper required in the various polyphase systems. It is assumed that a certain power has to be transmitted a given distance at a given voltage and with a given loss in a single line. The proportions of copper arrived at on these assumptions are :—

1.	Single phase	100
2.	Two-phase independent	100
3.	Two-phase Y balanced	100
4.	Two-phase mesh balanced	50
5.	Two-phase Y centre to earth	25
6.	Two-phase three-wire	72·6
7.	Monocyclic	100 + auxiliary
8.	Three-phase Y	75
9.	Three-phase Y common junction earthed	25
10.	Three-phase mesh	75

W. G. R.

596. *Electricity in Coal-Mining.* **J. P. Jackson** and **F. F. Thompson.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 469–477. Discussion, pp. 477–479. Oct., 1899.)—The authors point out the drawbacks of power transmission by means of steam and compressed air, and favour the use of electrical transmission, using direct current for haulage, and polyphase currents for pumping and driving fans, in spite of the disadvantages of a mixed system. The plant of the Davis Coal and Coke Company at Thomas, West Virginia, is briefly described, and curves are given showing the nature of the haulage and coal-cutting loads. Bare wires are preferred for all purposes in mines, though the danger to life is pointed out.

In the Discussion, **E. A. Sperry** emphasised the danger, especially with alternating currents, and stated that motors were generally too small for their work. **W. S. Aldrich** stated that the use of electricity enabled abandoned mines to be profitably reopened and deeper veins to be reached. A. H. A.

597. *Test of Railway Generating Plant.* **E. J. Willis.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 504–508, Oct., 1899.)—The plant tested consisted of a 300-H.P. Campbell-Tell water-tube boiler, a 300-kw., six-pole, G.E. railway generator, direct coupled to a Hoover, Owens and Rentschler

horizontal, tandem, compound, condensing engine running at 100 r.p.m. The feed pump and the condenser were operated by a separate boiler, so that all steam generated by the boiler passed through the engine. The water consumption was measured by a Worthington hot-water meter, which was accurately tested before and after the run. The draught at the grate was five-eighths of an inch. Readings were taken about every fifteen minutes. The load was as follows : One hour at 200 amperes, one hour at 300, one hour at 400, and one hour at 500 amperes. Some of the indicator diagrams are given, and the summary of the test, of which figures are given in full, is as follows :—

	Power.			Evaporation.		Coal Consumed.			Steam.			Efficiencies.		
Load.	Indicated H.P.	Electrical H.P.	Kilowatts.	Water per lb. of coal (actual).	Water per lb. of coal from and at 212° F.	Per indicated H.P. hour.	Per electric H.P. hour.	Per kw. hour.	Per indicated H.P. hour.	Per electric H.P. hour.	Per kw. hour.	Indicated H.P. per electric H.P.	Electric H.P. per indicated H.P.	Indicated H.P. per kw.
200 Amperes.	216	146	110	10·05	10·71	1·45	2·18	2·90	14·8	21·9	29·1	1·48	0·68	1·96
300 ,,	299	220	164	10·8	10·75	1·43	1·94	2·60	15·3	21·9	28·1	1·36	0·74	1·82
400 ,,	373	293	219	8·94	9·53	1·54	1·96	2·63	13·8	17·53	23·46	1·27	0·79	1·70
500 ,,	469	369	275	8·57	9·18	1·66	2·11	2·83	14·25	18·1	24.3	1·27	0·79	1·70

E. D. P.

598. *Electric Traction on the South London Railway.* **P. V. McMahon.** (Instit. Elect. Engin., Journ. 28 pp. 508–608. Discussion, pp. 609–632, Aug., 1899.)—This paper contains the results of tests and observations on electric locomotives on the underground City and South London Railway. The gauge of the line is 4 ft. 8½ in. The overall length of the electric locomotives, buffer to buffer, is 14 feet ; their width is 6 ft. 10 in. ; wheel base, 6 feet ; and diameter of wheels, 2 ft. 3 in. Each locomotive has two motors, the armatures of which are fixed directly on the axles. The motors are arranged in series, and the regulating gear consists of a reversing switch, which changes the armature connections, a simple rheostat switch in series with the motors, and a main break switch. Particulars of the motors are given.

The author goes somewhat minutely into the difficulties he had in getting a suitable dynamometer to register the draw-bar pull, and also the various stages through which the experiments had to pass before a definite line of action was decided on. The readings were taken at 5-second intervals on ammeter, voltmeter, tachometer, and dynamometer, and although the needles vibrated considerably, the numerous curves and tabulated data show that the results agree with very fair accuracy.

The author fixes the maximum acceleration, either positive or negative, at 1·46 feet per second per second, corresponding to stopping in 20 seconds from a speed of 20 miles per hour. This does not cause discomfort to the passengers, and it is not too hard on the brakes and wheels. If for practical reasons it is not desirable to adopt a higher negative acceleration than 1·46 feet per second per second in bringing the train to rest, there is clearly no need to try and get a higher positive acceleration at starting.

Particulars are given of tests with motors of larger size than those originally used on the locomotives, which the experience detailed in the earlier part of the paper showed were necessary. A series of observations

made on the effect of "varying the starting current" upon the acceleration of the train showed that with the ordinary series method of regulation the amount of current taken by the locomotive has not much effect (within fairly wide limits) on the time taken to run a particular section, or on the total energy drawn from the line.

Various experiments, which are detailed, point to the desirability of adopting series-parallel control in place of the ordinary rheostat switches first used. As the drivers were used to this class of switching-gear, a series-parallel controller, retaining the old form of rheostat switch, was developed. It consists of two switches operated by a single handle, that part of the controller which puts the motors into parallel being moved only at predetermined points. Magnetic blow-outs, or arc-suppressing devices, are not used, the motors not being put back into the series position until current is switched off.

In summarising, the author points out that :—

(*a*) The motor and locomotive tests show that, at starting, only about 73 per cent. of the total tractive effort at the tread of the wheel is given out at the draw-bar, and that the loss at starting is directly proportional to the tractive effort.

(*b*) After the locomotive commences to move, its losses decrease until a speed of about 9 miles per hour is reached, and then become fairly constant.

(*c*) The results of the draw-bar tests show that the tractive resistance per ton of train is 40 lbs. at the moment of starting, and that it drops quickly to 10 lbs. at 6 miles per hour ; between 6 and 13 miles per hour the resistance remains fairly constant, and then continues to rise almost proportionately to the speed, until a speed of 26 miles an hour is reached, when the resistance is about 21 lbs. per ton.

(*d*) Curves have a very important effect on the tractive resistance. Tests show that on a curve of 540 feet radius the tractive resistance is doubled. A comparison of the performances of several locomotives shows that the tractive force per ampere has an important bearing on the energy consumed for a given section. No. 12 locomotive, for example, with its low tractive force per ampere, takes 26 per cent. more energy than No. 15 for the shortest section, while on the longer section this is reduced to 6 per cent. For longer sections still, probably No. 12 locomotive would be more economical than No. 15.

(*e*) Although there is a great difference in the energy drawn from the line by the various locomotives, their efficiencies are not widely different.

(*f*) With plain series method of control the value of the starting current has not much effect on the total energy consumed for a given section. With the series-parallel method there is, however, a very great reduction in the energy consumed by adopting high starting-currents. The calculated performance diagrams show that, by altering the value of the starting-current when the motors are placed in parallel, there is a saving of 24 per cent. in time and 11·5 per cent. in watt-hours.

(*g*) Theoretically a higher rate of acceleration at starting is the more economical method of running a short section. The highest rate taken is 1·46 feet per second per second, the lowest that it was possible to adopt being 0·417 feet per second per second, the latter rate requiring 27·6 per cent. more energy than the former to run a 2,700-feet section.

(*h*) The acceleration at starting should be uniform, and to arrive at this the motor fields were successfully shunted during the starting period. Ex-

periments with No. 15 locomotive show that by shunting the field during the running period the energy consumed was increased about 50 per cent. without corresponding gain in speed.

(*i*) Calculations from tests show that a high rate of acceleration and a fair amount of coasting is a more economical method of running a short section than very rapid acceleration, necessitating the use of large currents for a few seconds and coasting for a large percentage of the time. The reduction in kilowatts per ton-mile, gained by very rapid acceleration, is deceptive, and must be considered in connection with increased cost of plant and the cost per kilowatt-hour.

Discussion.—**C. E. Grove** remarked that it did not seem to be sufficiently clearly recognised in the paper that the draw-bar pull is the total horizontal effort exerted by the locomotive minus that effort which is required to move the locomotive itself, and cannot, of course, be equal to the total effort of the locomotive. With regard to motor testing, he preferred the simple torque test to the Prony brake test. **A. M. Taylor** presented a curve connecting tractive resistance with speed, taken with one of the locomotives referred to in the paper. **R. P. Brousson** said that, according to his experience, the acceleration may be increased beyond 1·46 feet per second without discomfort to the passengers. What gives rise to discomfort is change in acceleration. Before changing from series to parallel the author allows the current, and therefore the rate of acceleration, to drop considerably. This would probably be felt by the passengers, especially when the trains are getting up speed. **R. H. Smith** advocated direct measurements of acceleration. **C. A. Carus-Wilson** said that in the first series of experiments made, the author had tried to increase the efficiency of the locomotive by simply increasing the number of turns on the armature. Under these circumstances, it is clear that in order to cover the given distance in the stipulated time it is necessary to shunt the fields. The effect of shunting the fields is to make the characteristic straighter than can be obtained from the simple magnetic curve of the motor; the efficiency at full load is slightly increased and that at light loads considerably diminished. Referring to the new locomotive which the author had designed, it is not surprising to find that he had not obtained a better ratio of kilowatt-hours to ton-miles. This is fully accounted for by the necessity for a larger driving wheel of 31 inches instead of 27 inches in diameter, to give clearance. **E. Wilson** gave a comparison between results obtained by Messrs. Siemens for locomotive No. 15 and those obtained by the author. **P. V. McMahon,** in replying, explained why no magnetic blow-out is necessary in the controller by stating that the paralleling contacts are not moved until the moment the motors are required to be put in parallel. Once the motors are in parallel they are left so until the current is entirely cut off. Referring to air resistance the author stated that measurements were taken, but there was great difficulty in getting accurate readings. He thought that the air resistance on the front of the locomotive in the tunnels was from 1 to 1½ lbs. per square foot at about 14 miles per hour. E. K. S.

599. *Buenos Ayres Electric Tramways.* **E. Manville.** (Street Rly. Journ. 15. pp. 693–700, Oct., 1899.)—Almost every street in the city has its tram line. The equipment is on American lines. Owing to high price of electrical energy, the feeder system is very complete: positive and negative boosters are used. A diagram of the distribution circuits is given, showing the calculations for drop of potential on trolley wires and rail return. To ensure good wear-

ing, the rails are made of best Bessemer steel containing not less than 0·45 per cent. of carbon, are cleanly rolled, each from a single ingot, are made to template throughout their entire length, and are carefully straightened by pressure and not by hammering. E. H. C.-H.

600. *Sheffield Corporation Tramways.* (Tram. Rly. World, 8. pp. 423–432, Nov. 2, 1899.)—About 24 miles of single line have been laid with 108-lb. rails and extra heavy 8-bolt fishplates, 3 feet long, weighing 80 lbs. per pair. The marine type boilers, 10 feet diameter by 10 feet long, have Ellis and Eaves' induced draught, "Purves" ribbed furnace and "Serve" tubes. Each evaporates 8,000 lbs. per hour at 160 lbs. per square inch. No tall chimney shaft is required, but each boiler has a short steel funnel just taken through the roof. There are three Allis-General-Electric 225 kw. sets, with 12 feet, 7 ton, flywheels. The guaranteed water consumption at three-quarter load is 18 lbs. per I.H.P. hour, condensing. The guarantees give an efficiency of 94 per cent. a full load, and 93 per cent. at half load.

Special braking arrangements include a trailing slipper brake, which removes the weight from the wheels and transfers it to wood blocks sliding along the rails: also electric brakes and trailing wedge blocks. E. H. C.-H.

601. *Haulage Systems Compared.* **T. Parker.** (Instit. Civ. Engin., Proc. 138. pp. 411–413, Oct., 1899; Engineer, 87. p. 565.)—Apart from other disadvantages, the cost per mile for horse trams with 26-passenger cars, weighing 2¾ tons empty, averages 7·78d.:—drivers' and conductors' wages, 2·50d.; horses, forage, harness, renewal, attendance, &c., 4·53d.; management and general expenses, 0·75d. For steam trams the average is 8·99d. per car-mile: drivers and conductors, 3·50d.; loco. and car repairs, 2·25d.; fuel, 1·65d.; lighting, 0·33d.; management and general expenses, 1·26d. Compressed air has better prospects of success than steam; the dead-load per passenger is less than with steam, and probably the efficiency greater. Endless-rope traction is obsolete. For gas engines on tram-cars there are no practical data. In electric traction the power per car-mile with accumulators is 4·6 E.H.P.-hours as against 2·15 E.H.P.-hours (and higher speed) with overhead wires. On the overhead system with a 30-passenger car weighing 4·3 tons empty, the costs per car-mile average 3·16d.:—drivers' and conductors', 2·49d.; generation, 0·46d.; car, 0·04d.; lighting, 0·02d.; management and general expenses, 0·15d. On the Liverpool Overhead Railway, electricity is under its worst conditions in comparison to steam, owing to the frequent stoppages; the average costs per mile there, with 140-passenger trains weighing 31 tons empty, are 4·32d., of which 0·42d. is for management and general expenses. For electric motor-cars the weight of accumulators has recently been reduced to ½ cwt. per H.P.-hour, or 5 cwt. of cells for a car which two years ago had required 16 cwt. The best example which the author has tested is: Weight of empty car, 9 cwt.; batteries, 5 cwt.; total, with 4 passengers, 20 cwt.; discharge, 12 amperes at 80 volts, giving 9 miles per hour on level with one motor making 1,200 revolutions per minute and double reduction gear: safe run, 40 miles. E. H. C.-H.

602. *Electric Railway Practice in America.* (Street Rly. Journ. 15 pp. 613–645, Oct., 1899.)—Compressed-air cars are now regularly operating the Twenty-eighth and Twenty-ninth Streets line in New York with great satisfaction; no data as to cost of operation are yet available. Over 90 per cent. of the entire street railway mileage in America is now operated

electrically, mostly by overhead trolley. In New York and Washington, with their efficient sewerage and favourable climate, the underground conduit system has worked well. In Chicago, twenty-five storage-battery cars have run over twenty-five miles of track for two years with fairly satisfactory results.

In roadbed construction the common practice is now to place creosoted ties, at about 30-inch centres, on a layer of broken stone, to spike 7-inch or 9-inch girder rails to the ties, and fill in between them with broken stone. Concrete substructure is costly and too rigid for passengers' comfort. Rails are almost universally ordered in 60-feet lengths, which nearly all mills can now supply. "Cast welding" has come largely into use; the verdict is that a smooth-riding track can be obtained and maintained by this means. The latest electric welding (see 1900, Abstract No. 605) is promising, though the cost is rather high.

In rolling stock the drift is towards long (30–35 feet overall) double-truck cars, even in some cities. Trail cars are abandoned as costing more for labour per passenger, largely increasing the accident account and involving switching difficulties at termini. On severe grades, or for rapid acceleration, the "maximum traction" type of truck is in general use. One of the most interesting experiments now being tried is the use of a "duplex" or "combination" summer and winter car, to overcome the difficulty of rainy summer days.

In motors the main qualities of the American type are: (i.) high efficiency through a wide range, (ii.) load and speed curves adapted to suit circumstances, (iii.) multipolar construction and separate coil armatures. Mechanical braking will shortly be adopted by many lines.

In power stations large size direct-coupled multipolar sets prevail, also water-tube boilers. In the best plants, economy in handling and storing coal has received special attention. Duplicate systems of piping are common, but many prefer "to place all their eggs in one basket and watch that basket." In the absence of condensing water, cooling towers have come into successful use. Nearly all the engines used in traction work employ modified Corliss valve gear. The largest steam set yet built is rated at 4,500 H.P. economical and 7,000 H.P. maximum load. In the best stations, power for railways has been produced at ¼d. per kw. hour, but in most it is still costing double this, these figures covering labour, fuel, water, material, and repairs, but excluding interest and depreciation.

In distribution, the latest practice is three-phase high-tension current distributed to substations containing stationary and rotary converters. Aluminium feeders are being tried.

Cable cars are now disappearing even from Chicago. In 1898 the Chicago City Railway Company operated its electric cars at 12·9 cents per car-mile, its cable cars (including trailers) at 10·8 cents, and its horse cars at 27·2 cents; while the earnings were respectively 22·7 cents per car-mile for the electric cars, 16·5 cents for the cable cars, and 16·6 cents for the horse cars.

The South Side Railway Company's generating station (one of the most economical in the world, its cost of operation being well below 0·75 cent per kw. hour) contains Allis-Westinghouse 4,000-H.P. sets, running at 80 r.p.m. under 160 lbs. steam pressure. It has Babcock boilers with automatic chain-grate stokers, fed by pendulum chutes communicating with steel storage bunkers over the boiler-room, into which coal is delivered by McCaslin conveyers. A water cooling-tower is used. Load fluctuations are lessened by two storage batteries, each about three miles from the central station, and each containing 263 cells of 750 kw. total capacity. They have given 4,300 amperes to the line. The batteries are in charge of the ticket-agent and

booking-clerk at one station and the train-despatcher at another, and the only duty of each is to throw in the circuit-breakers should they fly out. The average power output per car-mile ranges from 2 kw.-hours in summer to 3·52 kw.-hours in winter, the latter figure including electric heating of cars, and both including lighting, air compressors, station lighting, fans, and auxiliary motors. Coal screenings are chiefly used, costing 1·12 to 1·30 dollars per ton. The capacity of the fourteen chief power stations in Chicago totals 54,000 kw., the largest plant in one station being 9,600 kw. Photos of several stations are given.

The overhead construction is claimed to be durable and inconspicuous.

One large company uses No. 0 copper trolley wire with No. 6 silicon bronze guard wire. Silicon bronze is also used for span wires in the city; $\frac{5}{16}$-inch stranded galvanised in the suburbs. The insulation is "Aetna" throughout. Another company has abandoned No. 0 trolley wire in favour of No. 00, because of the latter's greater strength and of its assistance to feeders. Stranded $\frac{3}{8}$-inch galvanised span wires are used with it: and guard wires, which are now deemed a menace to life and property, have been taken down and abandoned.

Two engravings show all the types of line material ever used on the Chicago City Company's system, one representing the present standard, in which malleable or other iron has been abandoned in favour of brass, because rust deteriorates it and also bridges the insulation. Discarded brass is melted down and is found cheaper in the long run than iron. Three insulations are invariably used between trolley wire and earth. Solder is no longer used for splicing trolley wire or attaching hangers, but only for feeder joints: soldering is found to anneal the trolley wire and cause crystallisation and breakage. At about 75° F. a sag of 8 to 10 inches is allowed in all spans of 115 to 120 feet. Clinch ears are used: they move slightly if trolley pole catches in the span wires. Lattice poles are discarded in favour of tubular iron poles in three sections, 7 inches, 6 inches, and 5 inches diameter, weighing 850 to 900 lbs. Corner poles have sections 8 inches, 7 inches, and 6 inches in diameter; strain poles weight up to 1,200 lbs. Poles are set in 6 feet of concrete and rest on hard wood boards. At the street surface an iron thimble 12 inches long encircles the pole; the thimble is 1 inch larger in diameter than the pole and when the latter is in position, concrete is run in up to a flange on the thimble. Poles are repainted every three or four years and depreciate $3\frac{1}{2}$ to 4 per cent. per annum, as against cedar poles, $6\frac{1}{2}$ to 7 per cent. Lead-covered rubber cables are the standard. All return circuit cables within two or three miles of the power house are made 30 per cent. greater in section than the corresponding out-going cables.

The North-Western Elevated Railway has erected 75,000 lbs. of bare aluminium feeder of 1,300,000 circular mils section, in which a secret weld is used. The motors now in use include 1,688 of the G.E.-800 (25 H.P.) type, 755 of the corresponding Westinghouse pattern besides larger motors, the total number being over 3,000. As the result of careful tests, of which a tabulation is given, the G.E.-55 (150 H.P.) motor with "L" controller has been selected as the best equipment for the Lake Street and North-Western Elevated Railways. Electric heating is general, the "Consolidated" heater being the type most used. "Falk" cast-welded joints are now the standard, 100,000 having been made. Copper bonds are then omitted, care being taken to clean the rail ends with sand-blast before welding. A brief account is given of the New North-Western Elevated Railway now in progress. It is the first elevated railway built originally for electric traction. E. H. C.-H.

603. *Traction Data.* **W. B. Potter.** (Street Rly. Journ. 15. pp. 701-702, Oct., 1899.)—The General Electric Company's motors are rated at the H.P. which they will develop, with a temperature rise of 75° C. in one hour. The average H.P. required of a motor should not exceed 30 per cent. of its rating; its temperature rise under ordinary service conditions will then be about 60° C. If electric brakes are used the heating will be increased by 20 to 25 per cent. and a larger motor should therefore be used. The total H.P. (rated on the hour basis) for an ordinary city or interurban car may be taken as $\frac{1}{5}$(total weight in tons of 2,000 lbs. × maximum speed in m.p.h. on level). If electric brakes are used, $\frac{1}{4}$ should be written instead of $\frac{1}{5}$. The maximum speed is generally twice the schedule speed.

Excluding car friction, a tractive effort of 92½ lbs. per ton (2,000 lbs.) will produce an acceleration of one mile per hour per second on level track. On an ordinary street car the tractive effort during acceleration often rises to 200 or 300 lbs. per ton: on elevated or suburban lines 100 to 150 lbs. per ton is the usual maximum. From tests it has been found that the tractive efforts necessary to overcome rolling friction and air resistance are, for different weights and speeds of car, as follows:—

Weight of Car.	Speed, up to	Tractive Effort.
15 tons	25 m.p.h.	25 lbs. per ton.
15 „	50 „	50 „
25 „	25 „	20 „
25 „	50 „	25 „
100 „ (train)	25 „	15 „
Heavy freight train	25 „	6 to 10 „

The "tractive coefficient," or ratio of the total tractive effort to the weight on the driving wheels, should be at least 1:6. A series of tests gave the following results:—

	Tractive Coefficient.	
Dry rail	28 per cent.	Sanded, 28 per cent.
Thoroughly wet rail...	20 „	„ 25 „
Greasy moist rail.....	15 „	„ 25 „

To approximate the capacity of power station required for a given service, the average energy required may be assumed to be 100 watt-hours per ton-mile of schedule speed for ordinary conditions of city or interurban service. If the stops are a mile or more apart this figure may fall to 60 or 70 watt-hours, while frequent stops and very high schedule speed will increase it to 120 watt-hours, or more. E. H. C.-H.

604. *Westinghouse Electro-pneumatic Car-control System.* (Street Rly. Journ. 15 pp. 703–708, Oct., 1899.)—G. Westinghouse has evolved a system for moving the controlling apparatus on any number of motor-cars by means of compressed air, whose admission to the several parts is effected by electrically operated valves, circuits to which are manipulated by one multiple-contact switch. On an extension of the ordinary controller spindle are fitted ratchet wheels into which pawls engage on the ends of the pistons of the air cylinders. Applying the air-brake releases the controller. A new form of compound direct-connected rotary air compressor is used. A diagram of the electric and pneumatic connections on two motor-cars is given. Also particulars of a special truck. E. H. C.-H.

605. *Electric Welding of Rail Joints.* **R. F. Danforth.** (Street Rly. Rev. 9. pp. 575–577, Sept. 15, 1899. Paper read before the Street Railway Association at New York.)—Welding by bringing the abutting joints to a welding temperature has proved a failure because the homogeneity of the steel is destroyed. At Buffalo the Johnson Company are now using a method by which the ball of the rail never reaches more than a dull-red heat, the weld being made between facing strips at the centre and ends of the splice bars. The surfaces to be welded are pressed together with a pressure of from 3 to 35 tons per square inch. After the weld is made, the head of the rail is ground to a true surface by an emery grinder. About 250 amperes at 500 volts are required, being transformed by a rotary converter to 300 volts alternating, and then by static transformer to 5 volts. The contacts are water-jacketed. A machine will weld four joints per hour. Expansion is provided for by special joints every 2,000 feet, and by leaving bolted joints at the special work.

Welded joints require no bonding and do not cost materially more than bolted joints plus bonding. Cast-welded joints give as good a result mechanically, but the electrical contact is not as good. Out of 3,100 welded joints, 17 had broken. E. H. C.-H.

606. *Methods of Picking up Current on Electric Railways.* **M. Schiemann.** (Deutsche Zeitschr. Elektrotechn. 6. pp. 166–168, Oct. 15, 1899.)—Sliding contacts are not quite satisfactory for high speed electric railways because of the wear; also the heat generated may make the metal seize. The author thinks it is better to use rolling wheels mounted on the carriage axles, the face of the wheel being sufficiently wide to keep contact with the middle rail on going round curves. Necessary elasticity can be given to the wheel to keep good contact, by having the spokes fitted with springs. E. K. S.

607. *Underground Conduit and Three-Wire Trolley System.* (Tram. Rly. World, 8. pp. 379–384, Oct. 5, 1899.)—A description of the conduit system to be used by the London United Tramways on two miles of track between Hammersmith Broadway and Young's Corner, Chiswick. The conduit and track construction are illustrated, and are similar to those used in New York. The slot will not exceed $\frac{3}{4}$ inch in width. One hundred cars, carrying 30 passengers inside and 38 outside, will be provided on Peckham maximum traction trucks. Each car will be 33 ft. 4 in. overall, and will have two trolley standards for use on the trolley sections beyond the London boundary. There will be two trolley wires over each track throughout, the two inner wires being connected to form the neutral pole. The power station will be at Chiswick, and will contain three-phase plant at 5,000 volts and 25 periods. Eight miles of distant line will be operated from a substation with static transformation from 5,000 to 350 volts, and then rotary conversion to 550 continuous volts. The rotaries will also act as balancers. At first the services on the conduit and trolley sections will probably be independent.

E. H. C.-H.

608. *Street Railway Trucks.* **W. H. Heulings, Jr.** (Street Rly. Journ. 15. p. 809, Nov., 1899. Paper read before the Pennsylvanian Street Rly. Association.)—Most of the destruction of street railway tracks comes from badly constructed and not from heavy cars. Destructive power of a car varies as the square of its speed. Tests made as the result of litigation at New Orleans proved that 22-feet cars on maximum traction trucks consume no more power than 18-feet cars on single four-wheel trucks. E. H. C.-H.

TELEGRAPHY AND TELEPHONY.

609. *Kamm's Zerograph.* (Electrician, 44. pp. 145–146, Nov. 24, 1899.)—This is a type-printing telegraph by L. Kamm, and is an improvement upon a similar apparatus brought out two years ago. A flat spring moves over a lever which presses against a pin on the synchronising arm and forces it forward as soon as the arm is released by depression of a key. The travel of this lever can be altered by adjusting a screw. Originally the depression of a key energised a starting magnet which released the synchronising arm; but this is now done away with, and the disengagement of the arm is effected mechanically, as is also the contact sending a current to line. As formerly, when the arm reaches a position corresponding to the key depressed, a second contact is made. Formerly this closed the circuit of a "second-contact magnet," whose function was to send a second current to line. Now also a second current impulse is sent to line, but the "second-contact" magnet is replaced by a light armature added to the printing magnet.

To have the maximum number of signs with the minimum number of keys, there are two types, one above the other, on each type spring; and there is a special key, as on some typewriters, to change from upper to lower case. Ordinarily the upper of the two types would be struck against the tape and ink ribbon when the printing magnet is energised; but, when the shifting key is depressed, the type quadrant rises by exactly the difference in height between the two types, and the second type comes into action. When the other shifting key is depressed, the type carriage, upon which is the quadrant, is restored to its former position. The maker claims that the effect of capacity and inductance on a long line is minimised by the extreme brevity of the current impulse. The apparatus is said to have been tried successfully between Berlin and Frankfort upon an iron telegraph wire, upon a metallic circuit between Paris and Rouen, and is on trial in the G.P.O. in London, where it has been worked on an underground cable to Leamington.

E. O. W.

REFERENCES.

610. *Farmers' Telephones.* (Elect. Rev. N.Y. 35. p. 159, September 6, 1899.)—A small exchange used by farmers who have clubbed together and are connected by one trunk to the nearest town. M. O'G.

611. *Modern Telephony.* **A. R. Bennett.** (Feilden, 1. pp. 320–336, Oct., 1899. —Describes some constructive requirements and switching systems for telephonic communications. J. E. K.